THE AMERICAN GAS LIGHT JOURNAL

REDMAN & KENNY, N.Y.

PUBLISHING OFFICE No. 42 PINE STREET

DEVOTED TO THE INTERESTS OF ILLUMINATION, VENTILATION, WATER SUPPLY AND DISTRIBUTION, & GENERAL SCIENCE.

VOLUME LI.—No. 20. Whole No. 753. | NEW YORK, MONDAY, NOVEMBER 11, 1889. | $3 PER ANNUM, IN ADVANCE.

A. M. CALLENDER & CO., Proprietors. C. E. SANDERSON, Manager.
JOS. R. THOMAS, C.E., Editor. T. J. CUNNINGHAM, Asst. Editor.

ENTERED AT THE POST OFFICE AT NEW YORK, N. Y. AS SECOND CLASS MATTER.

Published on each Monday of the year, at No. 42 Pine Street, N.Y.

Terms of Subscription, Including Postage.—For the United States and Canada, $3 per annum. European countries, $4.00 (17 shillings—20 francs). All payments to be made in advance. Single copies, 10 cents.

Remittances should be made either by post-office order, registered letter, or bank draft on New York, payable to the order of A. M. Callender & Co.

Correspondence.—Wishing to make this JOURNAL a gazette of intelligent discussion to those of our readers who may wish to gain or give information on the subjects to which its columns are devoted, correspondence is solicited for publication from all who make the study of those subjects a pleasure or a profession.

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BRIEFLY TOLD.

CHEAPER GAS FOR CERTAIN DISTRICTS OF CHICAGO.—Despite all the hue and cry that is from time to time raised in official circles in Chicago over the gas rate of that city, the fact remains that Chicago's gas rate is quite a low one. Indeed, the wonder is, remembering the prodigality with which opposition charters were granted by the Councils of former times, that the rate is at its present low point. There can be no gainsaying the fact that the present management of the Chicago Gas Trust is conscientiously and persistently engaged in the effort to cheapen the process of manufacture—but not at the expense of deteriorating the quality of the product—to the end that the consumer and the Trust may be materially benefited. As it is in the city proper, so also is it with the supply of the suburban districts. In regard to the latter we note that, with the beginning of November, Secretary Yuille, of the Suburban Gas Company (Lake View district), and Secretary Bryant, of the Lake and Hyde Park district Gas Companies, notified their patrons that a good concession in gas rates had been determined on. In the Lake View instance, the gross is put at $1.60 per 1,000, with 25 cents off for payment within 12 days from presentation of accounts. In the Lake and Hyde Park districts, the gross is at $1.50 per 1,000, the discount and period of its availability being the same as at Lake View.

SOME VERY POINTED TRUTHS.—We are in receipt of a communication from a correspondent the greater portion of whose busy life has been devoted to the management of small gas works, and whose efforts in that direction have been crowned with substantial success. In view of the latter fact it is only fair to assume that his opinion concerning matters connected with such management is worthy of study, for, after all, it is the result of actual practice that is to determine whether or not a certain line of policy has been successful. The substance of our correspondent's communication is the following:

"Mr. Editor:—Permit me to say a few words concerning the management of small gas works. In my experience (which covers a period of 40 years) I have had wide and varied opportunity for inspecting such plants, and that opportunity has been frequently availed of. To sum up the results of such observation, I can, I think, truthfully say that the complaint of the greater number of the proprietors of such properties that investments of this nature are unprofitable is largely due to the blindness of the owners. In the first place, the owners of small gas works, as a rule, seem to think that a good business move has been made if they secure the services of a superintendent on the basis of a monthly salary payment of $50. The cheapest is never the best; that ought to be self-evident. To make a practical exemplification of this, let me say that a good many years ago I applied for the position of superintendent of a very small works—the plant was in very bad shape—when to my astonishment I was told that the salary of the former superintendent was $9 per week. I asked them to pay me fair wages, which, you may be sure, I put at a decidedly higher rate than they had been paying, and accompanied my demand with a proposition to the effect that if at the end of a year they found that I had not been worth the money to them they might, by retaining a certain portion of my monthly salary, save themselves any risk; but on the other hand, if

they found that under my management their property prospered, I was to receive the bargained amount, and that my services in the next year were to be paid for at a substantial advance. Whether I was successful or not, and whether they were satisfied or not, can best be answered by the remark that I remained in that Company's employ for something like 8 years."

Our correspondent goes on in a similar strain at some length, but his argument against the employment of cheap and inefficient superintendency is, we think, sufficiently strong in the portion above quoted. We have frequently urged this vital point upon the attention of owners of small gas properties, and anything that we would now say thereon could not help but savor of repetition. Still, as it is well to repeat good advice, we would earnestly say to such owners, and especially to those of them who complain most bitterly at the non-interest earning capacity of such investments, that no money is saved by the employment of a superintendent whose chief recommendation at the start is that he is willing to accept an abnormally low rate of salary. The same statement applies, and with equal force, to the medium and larger-sized plants as well. In fact, it is but a question of degree.

Lighting Tables for 1890.—We are in receipt of a copy of the "Lighting Tables" for 1890, published this year in separate form by the American Meter Company, in advance of that Company's usual issue of their annual year book or manual for engineers and superintendents. As with all the literature that emanates from this Company's offices, the lighting tables show satisfactory evidence of carefulness and accuracy of compilation, and are printed in good style. The Company explains that this departure was taken simply because the authorities in very many places make contracts for the public lighting well in advance of the first of January (about which date the regular annual is ready for distribution), and it was, therefore, presumed the gas companies would find the "Tables" timely and available. It might also be well to bear in mind that the edition of the "Tables" is not nearly so large in number as will be the case with the regular annual, wherefore it behooves those in need of the former to send on their orders at once. Of course, we presume it is understood that the "Tables" are intended for free distribution. The pamphlet furnishes two tables—one of which "follows the moon," while the second reproduces the all-night schedule regulating the public lighting of this city.

Some Further Account of the Life of the Late Francis M. Roots.—The following, respecting the late F. M. Roots, is from a local source:

"Francis M. Roots was born in Oxford, O., October 28th, 1824—his father, Alanson Roots, having moved there in 1816 for the purpose of educating his sons at the Miami University. Their ancestors were descendants of the old Puritan stock, who fled to America that they might worship God after the dictates of their own consciences. In 1845 the two brothers moved their woolen mill, which had been established in Oxford, to this city, operating the business under the firm name of P. H. & F. M. Roots. In 1849, F. M. Roots decided to go to California prospecting, still holding his relations here. This trip was taken with the party known as the 'Forty-niners,' and 600 miles of the perilous journey was accomplished on foot. Trials and ill-health at last forced him to return home, which he did in May, 1850. In 1860 he invented the rotary force blast blower, so well known in this country and Europe. In 1864 they purchased a small foundry and machine shop, which they have at times enlarged and improved until it has reached its present proportions. In 1870 F. M. Roots sold out his interest in the woolen mills to his brother, P. H. Roots, but still retained an equal interest in the blower manufactory. In 1872 he bought a large proportion of the stock of the First National Bank, of Connersville, and was elected its President in 1879, a position held by him at the time of his death. In 1881, '82 and '85, Mr. Roots secured patents on noted improvements in his blowers and exhausters. In 1882 the Connersville Furniture Manufacturing Company was organized as a joint-stock concern, of which, being a large stockholder, he was chosen President. In October, 1850, Mr. Roots was united in marriage to Miss Esther E. Pumphrey. Six children blessed their union, of whom but three survive—Daniel T. Roots, of Connersville, Mrs. E. D. Johnson and Mrs. Edwin Schively. These, together with his beloved and devoted wife, were near him when the dread summons came which took away a loving husband and a more than affectionate father. In 1851, under the auspices of P. H. & F. M. Roots, the Presbyterian Church School was organized; soon the building on Central avenue was erected, to which they were the largest contributors, and of which deceased and his family have always been devoted members. The Church loses in Mr. Roots a consistent and conscientious member and a most liberal supporter. Always charitable, no appeal passed unheeded, no suppliant was turned away. In the death of Mr. Roots, Connersville's loss beggars words. Philanthropic, energetic and aggressive, he was always most deeply interested in the prosperity and progress of the city. Enterprising, he gave to every charitable institution which would add to the interest of his home. The public good was before him always; the best interest of every new scheme for the mutual benefit of his city interested and engaged his heart and means. His name can be found at the head of every good work. There will be a vacancy, never again to be filled. A great light has gone out; a grand, noble heart stilled by death, but living ever in the hearts of the people of Connersville. In the foundry where so many hours of his life have been passed can be seen the saddened faces of his employees, mutely attesting to the regard in which they held their employer and benefactor. Many of these men who have been in his service for years will miss his admonitions and counsel; miss his cheering word and patient Christian bearing. The best testimony that we can bear to our dead is to say that in life they were fit models for the living. And that testimony can be truthfully borne in closing this brief history of the life and character of the late Francis M. Roots."

The Economist's Fuel.

The Boston *Advertiser*, in the course of an interesting article in which attention is called to the rapidly increasing use of gas in New England as a domestic fuel, notes that within the past few years a demand has sprung up for some simple and inexpensive method of cooking food and heating small rooms, some method less elaborate than those used by the hotel keeper. Two causes, doubtless, have combined to create this demand. The first of these is the greatly increased number of small families who practice what is called "light housekeeping." In every great city there are scores of young married men whose means will not allow, nor, perhaps, inclination prompt, the establishment of a household upon a complete scale. He has no family, possibly, except his young wife. Economy prompts him to hire a small flat, of perhaps three rooms, at a moderate rent. He is absent from home throughout the day, leaving for his work at an early hour and returning at sundown.

His wife is equally willing to escape the cares and perplexities incident to elaborate housekeeping. It is determined that the culinary department of the home shall be a matter of minor importance.

The result of this determination is the purchase of a gas or oil stove. It is snugly tucked out of sight in a closet, and the room which, with the presence of a coal range, would inevitably bear the name of kitchen, now poses as a modest parlor or reception room. It appeared to the mind of him who first devised this plan that gas was the proper fuel for consumption in these toy stoves. This term is used, since the first gas stove invented seemed scarcely more than a toy. It served its purpose in heating water, making tea, boiling milk, or warming the milk for the baby's midnight luncheon. But it was not long that the people were satisfied with this crude affair. Something by means of which more elaborate cookery might be performed was demanded.

The gas stove expanded in size, additional burners were added, broilers, bakers and other utensils were supplied until the housewife found herself with a full paraphernalia for cooking with gas as her fuel. The housewife liked this method chiefly "because it was so handy." There was no smoke, no dust, no ashes to sift, no coal to bring up. The gas stove was truly a labor-saving machine.

Soon it was suggested that the gas stove might readily be utilized for heating purposes. There were many small apartments, dressing rooms, bath rooms and the like, to which the heat of the stove or furnace failed to penetrate. This gas cooking stove proved a boon to the housekeeper of what is so often called the middle class. But the wealthy resident of the Back Bay and Beacon Hill early discovered the utility of the gas stove for heating. No sooner was it introduced than it became popular. At first the stove was identical with that used for cooking, with the top removed and a drum of sheet iron substituted. By this contrivance heating was done solely by radiation. Human ingenuity, however, devised better plans than this, until now a gas stove for heating is scarcely less elaborate in its mode of construction than the modern furnace.

There was still a step further yet to take in the manufacture of gas stoves. The æsthetic advantage of the open fire, whether of coal or wood, has always been conceded. It has been left to the makers of gas stoves to imitate the open fire, with wonderful success. The gas log was the first of these imitations, being an arrangement of asbestos piled upon andirons in the form of a heap of firewood. Small perforations permitted the escape of the gas which was introduced into the "log" through a flexible tube. The escaping gas, being ignited, furnished a flame at once grateful in its warmth and pleasing to the eye.

A more recent invention in this same line is a stove with open front, the opening showing a backing of corrugated copper brightly polished. A row of powerful gas jets above furnishes a strong heat, which is still more strongly reflected from the surface of the polished copper. This is one of the most beautiful forms of stoves for heating by means of gas.

Economy to Gas Companies of Gas Power for Operating Electric Light Plants.

The growth of the adoption of gas power for generating electric lighting currents has been shown from time to time in the columns of the JOURNAL, and this advance will naturally prompt the gas man directly interested in electric lighting to inquire for figures that will cause the economy of gas power to become evident to him. In most cases the cost of gas will be taken at the figure which represents its holder price, wherefore the cost of the number of cubic feet consumed in a given time and for a certain amount of work done will be compared with that of like results from steam power.

In keeping with the fact whether the cost of manufacturing gas is high or low, the result of the comparison may be favorable or not to gas power, but, no doubt, the showing so obtained would be a correct one, even in cases where the high cost of gas would seem to show that gas power was not the more economical. The fallacy of such comparisons, however, lies in the fact that the cost of gas is generally based on a given quantity sent out during the year, whereas if the quantity of gas made be increased these figures of estimate would not apply. Thus it is actually the case that where gas has been used for power purposes in driving the dynamo station of a gas works the retort house pay roll was not increased, while the revenue from coke and tar, over and above the usual amounts formerly received per ton of coal carbonized, was augmented.

There are indeed but few gas works that have reached the limit of their capacity so as not to be in position to produce 1,000 or 2,000 cubic feet more gas per hour to supply gas engines running 50 to 100 arc lights, and so gain the revenue from such service without increasing the number of benches under fire or the amount of stokers' wages paid. The majority of gas works doing business in towns having from 5,000 to 50,000 inhabitants, could secure an income from electric lights by simply keeping their retorts at higher heats, and the cost of the increased quantity of coal used would be offset in part or altogether by the receipts from coke and tar; especially and certainly in those districts where a good demand exists for these residuals.

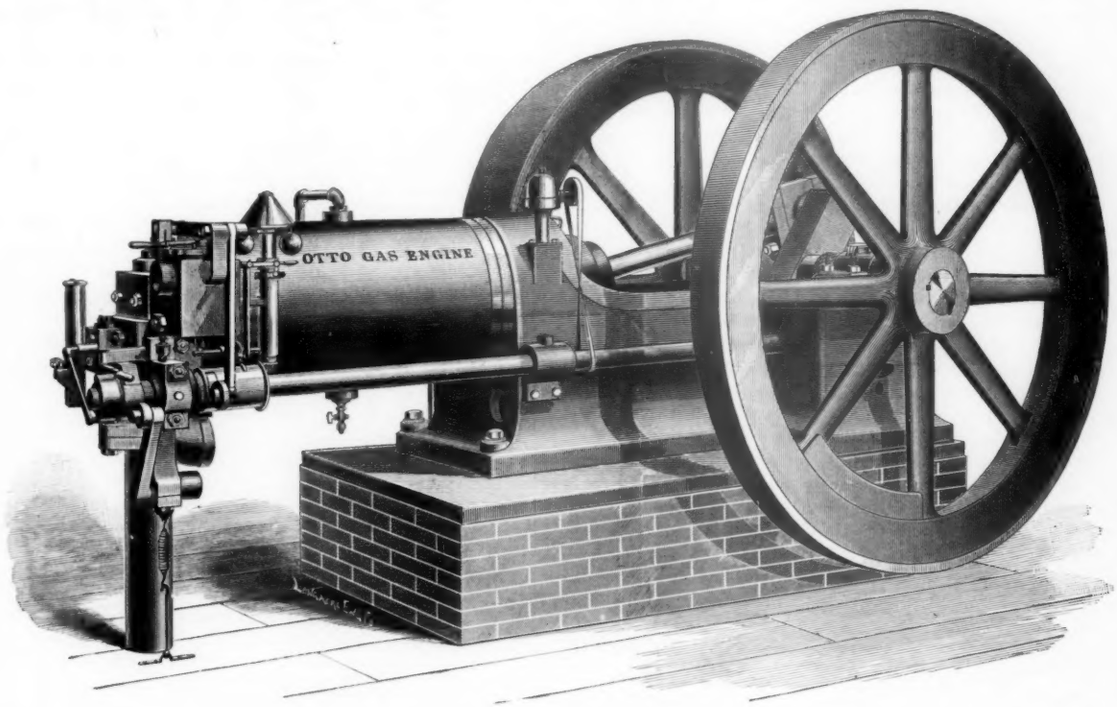
Those operating water gas plants could not count on this last-named factor, but, on the other hand, they have an ability to largely increase their production on short notice, and without increased expenses, in a much higher degree than coal gas works. In fact the proprietors of water gas plants were among the first to use gas power for driving dynamos. Their apparatus is not unlike the form of producer gas cupola type which is now frequently used in Europe for the obtaining of gas power, and at a cost of coal consumption per horse power unrivalled yet in the best and largest steam plants.

In the light of the foregoing statements it would seem that it is the small gas works, in which the cost of gas in the holder is at so high a figure—because of small output—that should strive to adopt gas power to gain the advantages of increased production, and so enable further progress in their business. However, should circumstances cause this proposition not to be tenable in some cases, appearances at least would be better conserved were those so situated to employ a small producer gas cupola for feeding gas engines and thus secure for themselves the lowest possible coal consumption—about 1½ pounds of coal—rather than to install steam plants and load themselves with new responsibilities. The ordinary retort house labor can be depended on to understand the making of producer gas, whereas special labor must be employed in the generation of steam.

The example thus shown the consumers will also have a valuable effect in that it will stimulate among them a desire to use gas engines of the smaller sizes in the furtherance of their pursuits.

Hitherto no mention has been made of the special feature of gas power for electrical work—which is that the fuel consumption is strictly limited to the time the power is used. Where fires under boilers have to be kept banked (oftentimes for a period in excess of that when the engines are being operated), steam cannot show to its best advantage.

We herewith illustrate the 50-horse power Otto engine, which is the size generally used at present by gas companies using gas power for the operation of electric plants, and it is the largest single-cylinder size made at the Otto gas engine works, Philadelphia.



(Concluded from p. 630.)

Instruments for Measuring Radiant Heat.

By C. V. BOYS, F.R.S.

LECTURE IV.

In any of the combinations of thermopile and galvanometer described in the last lecture the immediate effect of a current is the production of a twisting force or moment between the coils and needle, which produces a deflection in the movable part of the apparatus, that is, in the needle. If the needle were fixed, and the galvanometer coil movable, then the coil would be turned with the same force as before, but such a construction of apparatus would be impracticable. Supposing, however, an instrument with a fixed needle and a movable coil to be made, the deflecting force would be simply proportional to the strength of the magnetic needle, and therefore if, instead of a small needle, a powerful horse-shoe magnet were made use of, then just as the magnetic field in which the coil lies, due to the strong magnet, is stronger than the corresponding field due to the needle, so in the same proportion would the coil be more

powerfully deflected for any current by the magnet than it would be by the needle. The advantage of the increased field thus available is so enormous that the coil may be to a great extent reduced in size and complexity, and still leave a balance in favor of the combination of magnet and movable coil.

This was first effected in 1836 by Sturgeon, to whose researches in this direction Professor S. P. Thompson has directed my attention. They are published with his other work in a thick quarto volume.

Sturgeon used a variety of pairs of metals, which he generally combined by soldering to the extremities of a semicircular piece of wire made of one metal the ends of a straight piece made of the other metal. He then suspended these frames in front of one pole of a strong magnet, and heated one junction. The frames were deflected one way or the other, according to the junction that was heated or the pole of the magnet that was employed. I have made one of Sturgeon's frames, modified in detail only, in conformity with our modern knowledge, and I shall be able to show that this very simple contrivance is capable of showing very small effects of heat. It consists simply of a rectangular frame, of which the upper side and the two ends are made of copper wire, while the lower side is composed of two bars made of the alloys described in the last lecture, soldered end to end. A needle point is soldered to the middle of the upper side, which rests upon a piece of glass, so as to allow the frame to turn freely. The two poles of a strong horse-shoe magnet are thrust through the open frame without touching it anywhere, and an index of straw moving over a scale shows the deflection of the frame, and the direction in which it moves. A small piece of iron wire attached to the frame serves to bring it to the zero of the scale. If now a lighted match is held opposite to the center of the compound bar, the frame almost immediately begins to move in one direction, while if heat is applied to the ends of the compound bar, it instantly swings round and is deflected in the opposite direction. I may perhaps here remark that Sturgeon found that a coil suspended in a magnetic field made a most delicate barometer.

M. D'Arsenval has invented an instrument on this principle, which he showed at a meeting of the Physical Society of France, on February 5th, 1886. It consists simply of a pair of wires, one of silver, and the other of palladium, soldered together at their extremities, and forming a rectangular frame, with the junctions in the middle of the upper and lower sides. The frame is suspended by a single fiber of silk between the poles of a horse-shoe magnet, and is directed by a fragment of iron wire attached to it. He has made the frame of two different forms, either short and wide, in which case he places within it a fixed cylinder of soft iron, to increase the strength of the field in which the circuit hangs, or else very long and narrow when there is no room for an iron core; but in this case the legs of the magnet can be made so close together as to attain the same object. The deflection is read by means of a mirror in the usual way, but in this instrument the mirror serves a double purpose, screening, in addition, one of the junctions over which it is fixed from the influence of any radiation that might fall upon it as well as upon the other junction.

M. D'Arsenval has found that the instrument is very sensitive, and in the case of the long and narrow frame, that it is also exceedingly rapid in its movements and dead beat.

About a year after M. D'Arsenval had published an account of his instrument I heard of the results obtained by Langley with his bolometer, an instrument which, in his hands, became far more delicate than the thermopile. I felt that it was very unfair to the thermopile to compare it in its ordinary form, as made 30 years ago, with Prof. Langley's instrument, in the development of which all the knowledge and resources of the present day have been made use of. Owing to the very high electromotive force set up at a thermo-electric junction, and the very small temperature co-efficient of resistance of conductors, on which the bolometer depends, I fancied that if an instrument depending on thermo-electromotive force were designed and carried out as well as the bolometer had been, that perhaps a still more delicate and satisfactory instrument might be the result. It was in trying to solve this problem that I devised an instrument the same as Sturgeon's and M. D'Arsenval's in principle. Had I been aware that M. D'Arsenval had designed an instrument of the kind I should almost certainly have thought no more about it. It is perhaps well that I was ignorant of the work of this distinguished *savant*, for not only have I developed the theory of instruments of this class to a considerable extent, but I have made an instrument which I am sure is far more sensitive than his, and which at the same time must be less affected by numerous disturbing causes than any other instrument for measuring radiant heat that has been made, and in addition to this it was the difficulties that I met with in trying to find a suitable suspending fiber that led to the process for making fine fibers of quartz. In my instrument, which, at Gen. Donnelly's suggestion, I called a radiomicrometer, a circuit is suspended in a magnetic field. The circuit is composed of three metals, as follows: There are, in the first place, two very small bars of antimony and bismuth, or, preferably, of the alloys to which I have so often referred, which are soldered side by side at their lower ends to the side of a small disc, or, for spectrum work, to the end of a narrow strip of copper foil, on which the radiation is to fall, as in Lord Rosse's thermo-junction, while their upper ends are soldered to the ends of a long, narrow ∩-shaped piece of copper wire, which completes the circuit. The upper end of the copper stirrup has soldered to it a small piece of straight wire, which is cemented into the end of a very fine glass tube. At the upper end of the glass tube is fixed a small plain mirror, and the whole is suspended by a fine quartz fiber in a narrow hole in a mass of brass, or, better, of copper, between the pole pieces of a powerful magnet.

I have investigated the theory of this instrument with the view of obtaining the best possible result. The main conclusions are, I think, of sufficient interest to bring before your notice.

In the first place, it follows, for reasons similar to those advanced in the discussion of the thermopile and galvanometer, that the dimension of the moving system should be as small as it can be made, provided that whatever size it is made the several parts are properly proportioned. The limit of smallness is practically determined by the bars of antimony and bismuth, or of alloy, because of the difficulty of making and soldering such materials when excessively thin. I find by experience that I have no difficulty in making these bars far finer than any which at first I expected it would be possible to handle, and in soldering them at each end, and even, if necessary, taking a circuit to pieces, cleaning off the solder and re-soldering, when they are no more than one-two-hundredth of an inch thick, and one-fiftieth of an inch wide, that is so fine that 30 of them could be packed in the space occupied by a single bar such as is used in an ordinary thermo-electric pile of 80 pairs.

Now, whatever size is given to the bars, it is clear that for any size of bars there is some thickness of copper wire which is most suitable, for if it is made very thin indeed the conductivity of the suspended system will be reduced in a higher ratio than the moment of inertia; on the other hand, if very thick, the moment of inertia will be increased in a higher ratio than the conductivity. But what is not immediately evident is that no matter what shape or size or number of turns may be given to the copper wire, one particular thickness is better than any other. This is given by the relation—

$$a = \frac{1}{b}\sqrt{\frac{Kv}{Cu}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Where a = the sectional area of the copper wire.
b = the breadth of the circuit (assumed small compared with the length).
Where u = the moment of inertia of a unit piece of copper ($1 \times .1 \times .01$ cm.) at 5 mm. from the axis.
v = the resistance of a unit piece of copper.
K = the moment of inertia of the bars, mirror and connecting tube.
C = the resistance of the bars.

There must also be some size of circuit which will give the best result, that is the greatest deflection in a given field, and with a given period of oscillation, for if made very large or very small, more is lost than gained. The best area for the circuit to enclose is given by the equation—

$$A = lb = \tfrac{1}{4}\sqrt{\frac{KC}{uv}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Where the symbols have the meanings already given, and in addition—
A = the area enclosed by circuit.
l = the length of circuit.

In all cases one turn of copper wire is better than any greater number. It does not matter how l and b are modified so long as b is kept small compared with l, and so long as their product is not allowed to change. Under these conditions the area enclosed by the circuit, the moment of inertia, and the resistance of the circuit all remain the same, and therefore the sensibility is not affected.

When a and A have the values given by the two equations above, the following very simple relation will be found to hold. The resistance of the copper part of the circuit is equal to the resistance of the bars, and the moment of inertia of this copper is equal to the moment of inertia of the bars, the mirror and the connecting stem. Further, what I have called the efficacy of the combinations, that is the sensibility in a unit magnetic field, is—

$$E = \tfrac{1}{8}\frac{1}{\sqrt{(KCuv)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Though this is the circuit which will give the greatest deflection in any field when mounted so as to have any given period, it does not follow that it will be the most convenient one to use in a very strong field. The force tending to move the circuit, and the ultimate deflection, is proportional to the strength of the field, but the resistance to the motion due to the reaction between the field and the current induced by the motion is, for any speed, proportional to the square of the strength of the field; and so, though with weak fields the circuit may move readily enough, this is not the case when the field is strong, even though the force urging it to move is greater. I can show the effect of this "damping" by a simple experiment. There is suspended between the poles of a magnet a circuit made of copper only, and the strength of the field in which it hangs may be varied by moving the pole pieces of the magnet. At present the field hardly exists; and so the copper circuit is able to oscillate freely, and in consequence to make many swings before it comes to rest. On increasing the strength of the field it is evident that the circuit is not so free as before, because any swing is only a small fraction of the one before it, and after four or five oscillations it ceases to move. On further increasing the strength of the field the oscillations fall in amplitude at a still higher rate, and they seem each to take very little longer, but there are fewer of them before the visible movement comes to an end; at last the resistance to the motion becomes so great that the circuit when displaced moves up to its position of rest, and is unable to pass beyond, but now it takes an appreciably longer time to make the half swing than it did before. On still further increasing the field the resistance becomes so great that the circuit is hardly able to move at all, but very slowly creeps along, and may take ten or perhaps a hundred times as long to come to its resting place as it did in the last case.

The question that then arises is what is the most suitable field to employ; if it is weak, the circuit will oscillate so freely that owing to the number of swings it may take a long time to come to rest, and further, the deflection will not be great. If the field is as strong as it can be made, the circuit may meet with so much resistance to its motion that it will take an enormous time to come to rest, though it is true the deflection, when it can be read, will be much greater. It will make it easier to come to a just conclusion, if I state in a few cases to what extent the period of oscillation is increased when the resistance to the motion is sufficient to produce certain definite decrements in the amplitude of the oscillation.

	Ratio of any oscillation to the one before.	Period of oscillation.
Undamped	1	1.00
"	$\frac{1}{2}$	1.02
"	$\frac{1}{5}$	1.12
"	$\frac{1}{10}$	1.24
"	$\frac{1}{100}$	1.77
"	$\frac{1}{200}$	1.96
"	$\frac{1}{1000}$	2.42
"	$\frac{1}{10000}$	3.10
"	$\frac{1}{100000}$	3.80
"	$\frac{1}{1000000}$	4.51
Dead beat	$\frac{1}{\infty}$	∞

Now, the strength of the field should be so chosen that the resistance to the motion of the circuit caused by it is not quite sufficient to make the motion perfectly dead beat. Supposing that it is possible to observe a deflection accurately to, say, one-thousandth of the whole, it is not only useless to make the decrement less than $\frac{1}{1000}$, but harm will be done because of the rapidity with which the time of coming to rest is increased when the magnetic field is made stronger. On the whole, I think it is preferable to have the decrement such that the elongation of the first swing beyond the position of rest is just distinguishable as an elongation, for then it is possible to make a definite reading in a very short time, a matter of importance when experiments are being carried on under variable conditions.

However, it is a matter of little consequence whether the ratio of damping is very small, or whether the motion is just dead beat, what is really important is that the resistance shall not be more than sufficient to make the motion dead beat. If, for instance, the field that is just sufficient for the dead beat conditions is doubled in strength, then though the ultimate deflection obtainable may be also doubled, the velocity of motion will be halved, and it will take four times as long for the circuit to apparently come to rest.

Now when anything, as in the case here, is subject to a force proportional to the displacement, and to a resistance proportional to the velocity, the motion will be just dead beat when half the resistance at unit velocity is equal to the square root of the controlling force at unit displacement. It may be proved that when the circuit is made of the dimensions which equations (1) and (2) show to be best, the value of the magnetic field H, that will just make the motion dead beat, is given by the equation—

$$H = 8\sqrt{\frac{\pi}{\tau}}\sqrt{(uv)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

in which τ is the complete period of vibration (undamped).

Since the symbols K and C have been eliminated, this shows that, no matter what the bars are made of, or what dead weight is fastened to them, provided the copper part of the circuit is formed so as to give the greatest efficacy, the magnetic field that will just make the motion dead beat, conveniently called the dead beat magnetic field, will always be the same, and this depends simply on the properties of copper, and the period that is chosen.

It follows from equations (3) and (4) that the sensibility S, obtained by the best circuit in the dead beat magnetic field, may be found from the relation—

$$S = \sqrt{\frac{\pi}{\tau}}\frac{1}{\sqrt{(KC)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

which is independent of the properties of copper. It thus appears that the sensibility obtained by the above combination is not affected by the nature of the material with which the circuit is completed, so that badly-conducting metal, or even glass, would be as good as copper. This very paradoxical result may be explained by imagining what would happen if a specimen of copper could be found with 100 times its proper resistance. Under these circumstances, equation (1) shows that the wire would have to be made with 10 times the sectional area, and equation (2) that it would be 10 times as short, and thus both the resistance and the moment of inertia of the circuit would be the same whichever metal were used. Now equation (4) shows that the field would have to be 10 times as strong, from which it immediately follows that the motion must still be dead beat, if it was so before, since the circuit has the same moment of inertia and the same resistance as before, but encloses one-tenth of the space in the magnetic field, which confirms equation (4), and that the sensibility must be unchanged, which confirms equation (5). Of course, practically, glass could not be used to complete the circuit, because with such bars as it is possible to make, the thickness of the glass would become enormously greater than the length of the circuit, which must, by original assumption, be large compared with the breadth, and because a magnetic field of an almost infinite strength would be necessary.

The actual strength of the dead beat magnetic field, that corresponds to the material copper and the arbitrary period 10 seconds, is almost exactly 272 *C.G.S.* units. Now, since it is easy to obtain a field four or five times as strong as this between the poles of a permanent magnet, it is a question whether it will be possible to use a much stronger field with advantage, not varying some of the other conditions, for that would cause a resistance to the motion of the circuit of from 16 to 25 times that which is necessary to make it dead beat, so that it would require from 16 to 25 times as long a time in which to come to rest, but with such a modification in the circuit as will keep the motion dead beat. The thickness of the copper wire must not be altered, but the size of circuit may be reduced as the field is increased in strength, so as to maintain the dead beat relations, and the result is a slight gain in sensibility. Calculation shows that if the field is made M times as strong as the dead beat magnetic field, the area must be made $(2M-1)$ times as small, while the sensibility of the combination will become $\left(2-\frac{1}{M}\right)$ times as great. Thus with a field four times as strong, the sensibility will be $1\frac{3}{4}$ times as great, while with an infinite field it could not be more than doubled.

The practical conclusion, then, is that if a circuit is made approximately of the best proportions, the field may be varied by sliding the pole pieces until a convenient decrement is produced, when the sensibility will not greatly differ from the greatest which it is possible to obtain.

I may mention also that the size of the mirror is a matter of some importance. If large, so as to give plenty of light, say as large as the mirror of an ordinary reflecting galvanometer, the moment of inertia would be so enormous as to completely spoil the instrument. If very small, so as to have a negligible moment of inertia, it would neither reflect enough light nor would it on optical grounds be capable of defining sufficiently well. That size is best of which the moment of inertia is about one-third that of the bars. I found that mirrors made of the thinnest microscopic cover glass, one two hundredth of an inch thick, and about one-eighth of an inch square, silvered at the back, fulfilled these conditions in the case of the particular circuit that I have in the instrument

upon the table. I have found that the definition of such a mirror, if properly made and mounted, is so good that it will produce an image of a cross wire upon a scale one meter distant, which is a sharp black line not much more than one-tenth of a millimeter wide, and which can certainly be read to this degree of accuracy. I have not found that galvanometers are usually read more accurately. It is, of course, necessary in the case of these small mirrors to employ a brighter light than a lamp flame, but, with oxygen at its present low price, there is no reason why a small lime light should not be used.

The following dimensions, which are nearly those given by the equations, I have found by experience to answer well, and to be not so small as to be too difficult to make: Thermoelectric bar $\frac{1}{2} \times \frac{1}{50} \times \frac{1}{100}$ inch. No. 36 copper wire made into a circuit one inch long, and about $\frac{1}{10}$ inch wide, a copper heat-receiving surface, blackened on the side exposed to the radiation $\frac{1}{10}$ inch in diameter, or $\frac{1}{4} \times \frac{1}{10}$ inch. Mirror $\frac{1}{10}$ inch square, $\frac{1}{1000}$ inch thick. Quartz fiber 4 inches long, $\frac{1}{1000}$ inch in diameter.

The complete circuit connecting stem and mirror *m* is shown in Fig. 10. One of these circuits that I made weighed less than half a grain,

Fig. 10.

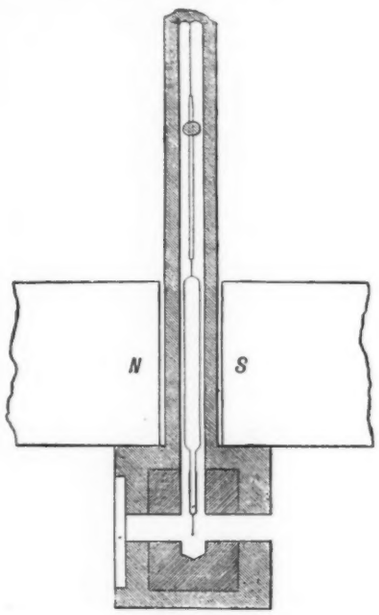


Fig. 11.

and though there were five soldered joints, the total weight of solder used did not exceed $\frac{1}{15}$ grain.

There is one point that I should mention. The disturbance caused by the magnetic qualities of the antimony and bismuth bars, small though they are, was so great as to make the instrument completely unusable; but this difficulty was overcome by making the center of the block of metal in which they hang of iron, as shown by the darker shading in Fig. 11. This screens off the magnetism of the pole-pieces from the bars, but leaves the rest of the circuit in a strong field. The copper wire used must be carefully chosen, as much is so magnetic as to be useless; when a non-magnetic piece is found, it must not be cleaned with emery, or it will become evidently magnetic. I mention this to show how feeble the forces are that are used, and when I say that the instrument is perfectly free from every influence except that of radiation upon the receiving surface, it will be evident that the effects of many disturbing causes which ordinarily give so much trouble have been very completely avoided. A strong magnet may be moved about close to the instrument, but no effect whatever can be observed. Magnetic disturbances are the most fruitful source of trouble with the ordinary galvanometer; for instance, it is not possible to do any serious work with a galvanometer in the Science Schools, South Kensington, except at night, because of the movements of a hydraulic lift, of which the ram is a huge weak magnet, presenting in its movements alternately north and south poles to every instrument on the ground floor. There are no connecting wires or binding screws, and so no uncertain thermo-currents are set up, nor induced currents due to the movement of the connecting wires through the earth's magnetic field. The sensitive part of the instrument is very small, and is enclosed in a narrow hole in a solid mass of metal, which, moreover, is protected by being enclosed in a wooden case, and so temperature changes in the room, and hot and cold draughts, are not felt. The instrument is very quick in its indications; its sensibility and its decrement can be varied at will. The following figures, obtained by

	Deflection.	Deflection. / Heat.	Deflection. / Heat × time.
Elliot pile and galvanometer	1	1	1
Radio micrometer	4.2	560	2,000

experiment from the instrument now on the table, show to what extent it is more sensitive than the standard thermopile and galvanometer, as measured in the three ways described in the last lecture. This sensibility has not been obtained at the sacrifice of stability, for none of the other instruments will compare with this in its freedom from the influence of every kind of disturbing cause.

Calculation shows that the instrument ought to give a clear indication when the sensitive surface has been warmed one two-millionth of a degree Centigrade, and the experiment shows that it will clearly respond to a quantity of heat no greater than that which would be radiated on to a halfpenny by a candle flame 1,530 feet away from it.

There is one other class of instrument for measuring radiant energy, which has lately been brought to a great perfection more especially by Prof. Langley. Instruments of this class depend upon the change of resistance of a conductor when warmed. The earliest account of an instrument of this kind, for the reference to which I have to thank Dr. Baur, is one by A. F. Svanburg, who made one of the arms of a Wheatstone's bridge, of a flat spirial of copper wire $\frac{1}{120}$th of an inch thick, covered with lamp black. When this spiral was exposed to radiation, it was warmed to a certain extent, and so its resistance was changed, disturbing the balance of the bridge. He found this very simple contrivance to be extraordinarily sensitive, and better, he believed, than the Nobili thermopile.

It does not appear that much use had been made of instruments depending upon the effect of temperature upon resistance until 1881, when Langley turned his attention to this class of instrument. However, Jamin and Siemens had contrived apparatus in which the change of resistance disturbed the equilibrium of a differential galvanometer.

The general theory of the actinic balance or bolometer is given in the *American Journal of Science*, vol. xxi., p. 187. From this paper it appears that Langley did not find the thermopile sufficiently delicate to detect and measure the energy in a diffraction spectrum. In the case of the thermopile and galvanometer, the work that is necessary to deflect the needle must be supplied by the energy of the radiation, in fact, a great deal more must be supplied, because nearly all the heat received by the pile or junction is carried by the Peltier action of the current to the cooler junction, and but a small fraction is converted into electrical energy, only part of which is transferred to the needle. In the form of instrument first used by Svanburg, the energy that is necessary to move the needle, is not derived from the radiation at all, but from the cell or battery employed to send the current through the Wheatstone bridge. All that the energy of the radiation has to do is to direct that of the battery, for when one of the resistances in the bridge is increased, and the balance disturbed, some of the energy of the battery spends itself in the galvanometer. The material which Langley found most suitable for the resistances were steel, platinum, or palladium, in the form of the thinnest possible ribbon. In the case of iron, the change of resistance is 0.4 per cent. for each degree Centigrade. The object of using ribbon as thin as it can be made is to cause it to come to its final temperature as quickly as possible.

The effect of the size of the ribbon is not at first very evident. Suppose a bolometer made with a strip of metal of some particular size, and that another identical instrument is made, in which the strip that is to be exposed is half the breadth. Then its resistance will be the same; and since in the smaller strip there is only one quarter of the metal to heat, and it exposes one quarter of the surface to the radiation, it might seem as if it should acquire the same temperature as the larger piece, and so the change of resistance in each case should be the same, and thus the smaller piece receiving the smaller quantity of heat seems as if it should be able to produce the same effect as the larger. Now there are several false assumptions in this reasoning. In the first place, when these strips of metal are warmed, however slightly, above the rest of the instrument, heat begins to escape by radiation, convection, and by conduction. The radiation would, for any rise of temperature, be itself proportional to the surface, and so would produce the same effect in the two cases; the same would be almost true of the heat lost by convection; but this would not be the case at all with the loss by conduction, so that on this account the smaller surface would not be heated to so great an extent as the larger. However, even supposing that they were heated to the same extent, when no current passed, the smaller piece

would not be capable of causing so great a movement of the galvanometer needle. It must be remembered that the battery current itself, in passing through the several resistances, must heat them to a certain extent; but as the exposed strip is electrically balanced against another strip in the same tube, but not exposed, this alone does not disturb the balance, unless the current is so strong as to heat them sufficiently to set up strong convection currents in the apparatus. Now in the case of the larger strip, a stronger current can be sent than through the smaller before this occurs, and since they are of the same resistance, a stronger current in the galvanometer will be the result.

In another way the heat produced by the battery current and that developed by the radiation to which the instrument is exposed, are curiously involved together. Suppose that the radiation acting alone were able to heat the exposed strip so as to increase its resistance to a certain extent, and the current acting alone were able to heat both strips to some other (generally a far greater) extent, then when both act together there will not be the same difference of temperature as if the battery current were not passing, and for this reason. Any increase of temperature in the exposed strip, by increasing its resistance, diverts a certain proportion of battery current into the other, and thus more heat is developed in the covered strip by the battery current than in the exposed strip, and this tends to counteract the effect of radiation. Thus apparently heat is carried from the warmer to the cooler strip, just as in the thermo-electric apparatus the Peltier action carries heat from the warm to the cool junction. An exception to this, however, is found in the case of carbon, which falls in resistance as its temperature rises. In this case the heat received by the exposed strip warms it, lowers its resistance, and causes a greater proportion of the whole current to pass through it, which warms it still more.

Langley has, by making every detail as perfect as possible, and by employing the most delicate galvanometer that American ingenuity could construct, been able to map the dark heat of the spectrum, and to extend it far beyond the limits which previously were known.

Dr. Baur has published two papers on the bolometer. He made his grating of tinfoil, cut in the form of a series of parallel strips joined at alternate ends, a form which Langley also used, supported at the ends of the strips only, and blackened with platinic chloride. Such a sensitive surface acquires its final temperature almost instantly, and the time that elapses before a reading can be taken depends simply upon the galvanometer. Dr. Baur tried to use Dutch gold and gilt paper, but these were found impracticable. There is a difference in detail between the arrangements of Langley and Baur in respect of the second resistance, against which the exposed surface is balanced. In Langley's instrument this second resistance is made in two halves, placed on either side of the exposed surface so as normally to have the same temperature. In Baur's arrangement the two resistances are arranged side by side, and by the movement of a shutter the radiation is allowed to fall on one or the other alternately, and thus the effect is doubled. In order that these two resistances should be exactly alike, a piece of foil was doubled, and the two cut out of the doubled piece at the same time.

I understand from Dr. Baur that this class of instrument is in use in the laboratory of Professor Helmholtz, and generally in Germany to a much greater extent than it is with us.

I have had no experience with any of the instruments of the bolometer type, and so cannot speak of them from experience; but it is possible that in sensibility Prof. Langley's instrument may not be far short if it does not actually exceed, that of the radiomicrometer. But it cannot compare with the radiomicrometer in its freedom from disturbing influences. On the other hand, the bolometer has the very great advantage over all the instruments except the thermopile, that it can be moved about and pointed up or down, whereas the radiomicrometer must be kept level, and is most easily used when fixed, so that the radiation must be brought to it, a plan which in some cases is not convenient.

A few words on the relative advantages of the different classes of instruments may perhaps be conveniently given here.

It sometimes happens that the radiation to be measured is brought to an exact focus, which is a line in the case of a spectrum, or a point when a star is being observed. In these cases, instruments like Joule's convection apparatus, the differential air themometer, or a Weber's micro-radiometer are useless, since they are only efficient when advantage is taken of the large surface they expose to the radiant energy. The receiving surface should be no larger than the image formed, and so even the thermopile itself is practically of little use. A thermo-junction is good, but the bolometer for spectra, and the radio-micrometer generally, are the only instruments that can be used with advantage.

If diffused heat is to be measured, then the instruments first mentioned are at their best, but those with small receiving surfaces are better if reflecting mirrors or rock-salt lenses can be employed to concentrate the rays upon the small surface.

If the instrument has to be freely movable, the thermopile and bolometer are the only ones which can be used at all; if it need be moved only slowly, and may be kept level, then the radio-micrometer and one or two others also become available.

If the instrument is to be exposed to outside changes of temperature, the radio-micrometer is the only one which is practically uninfluenced.

If magnetic changes, which are by no means uncommon, are liable to be met with, the radio-micrometer and Joule's instrument are the only ones available.

With regard to my instrument, and M. D'Arsenval's, I have no doubt that mine is far more sensitive and the least influenced by disturbing causes, for I employ a thermo element which has an electromotive force ten times as great as any that he can make use of. He is able to suspend his circuit by a fibre of silk, which would make the radio-micrometer practically unmanageable. He has not, so far as I know, screened off the disturbing effects of temperature changes by surrounding the circuit with a mass of metal, and if this were done, since the junctions are much further apart in his instrument than in mine, any temperature waves moving in the metal block would have a greater effect; but what to me is most conclusive of all, is the fact that he fixes the mirror over the junction that is not to be exposed to radiation.

And now, in conclusion, I have to regret that it has not been in my power to treat the subject of these lectures either so clearly or so thoroughly as I should have liked. The only claim that I have to address the Society of Arts at all upon the subject is the fact that I have done something to develop some of the instruments which I have brought before your notice.

Midland Gas Managers at the Birmingham Compressed Air Company's Works.

The London *Journal* says that the members of the Midland Association of Gas Managers had a pleasant meeting in Birmingham on October 17th. The programme comprised discussions on the papers of Mr. Ferguson Bell and Mr. W. T. Tew (both of which were submitted at the preceding meeting at Derby and Matlock), besides a visit to the works of the Birmingham Compressed Air Company, and the usual formalities of an ordinary meeting of a District Association of Gas Managers. It was the occasion for the leave taking of Mr. Taylor, of Derby, who has filled the Presidential chair during the past year with much credit to himself and advantage to the Association. His successor is Mr. H. Peaty, of Burslem—a very popular member, and worthy representative of the Staffordshire section of the Society. Fitting acknowledgment was made, both during the business part of the meeting and during the subsequent dinner, of Mr. Taylor's services; and a hearty reception was accorded to the incoming President. The chief technical subject brought before the members was water gas, raised by Mr. Bell's paper; and although the discussion of the topic was not exhaustive, and indicated clearly enough that practical experience of the working of water gas plant was lacking, it cannot be complained by friends of this kind of gas that the Midland Gas Managers regard it with any sort of prejudice. Mr. Bell, indeed, was very trenchant in his criticisms of water gas schemes, and seemed to think that under no probable circumstances could water gas be of much account in England; but even he did not expressly object to a declaration by Mr. Ellery, that if this description of gas could be made at about the ordinary cost of coal gas, or less, he would not have the slightest objection to adopting it. In fact several members seemed to think that there might be circumstances where water gas plant would prove useful in an English gas works, even though it were a little more costly to make. It would not do, however, to allow water gas projectors to flatter themselves from the manifestation of this tolerant spirit among English gas managers that the day for the adoption of water gas plant in English gas works, even as an auxiliary, is within the range of practical gas politics. It is as yet far too costly for anything of the kind. Water gas enthusiasts must not blind themselves to the fact that the gas of 16 or 17-candle power, which English gas companies can sell in places for about 2s. 3d. per 1,000 cubic feet, costs in the holder only about 8d. per 1,000 cubic feet, which is less than half the cost at which any known system of wafer gas making can produce an equivalent article. If Russian crude oil is ever piped across from Baku to the Black Sea, and imported into this country by means of tank steamers, it is difficult to see how it can be put into gas works on shore for less than 3d. per gallon. This is the cheapest source to which we can look for a fluid mineral hydrocarbon suitable for carbureting water

gas; and it is difficult to imagine that it can ever be sold in England at the figure named. Even this, however, would not be cheap enough to make carbureted water gas compare favorably, in point of cost, with ordinary coal gas. The prospects of water gas, or cheap fuel gas, distributed uncarbureted for uses other than lighting, received a striking illustration from what the members of the Midland Association saw and heard later at the compressed air works. Before visiting this establishment, however, they discussed Mr. Tew's paper on the effects of temperature in relation to unaccounted-for gas, which brought out several interesting practical observations concerning meters, mains, etc.

The undertaking of the Birmingham Compressed Air Company has been described and discussed several times in the *Journal*, from the time when the scheme was first propounded and reported upon favorably by Sir F. Bramwell and Mr. Piercy. After much delay and the overcoming of many difficulties the scheme has been realized; and at the present day Birmingham counts the compressed air supply among her most noteworthy manufacturing advantages. Although the works are not yet out of the contractors' hands, a shift has been made to get a section of the plant in operation; and the Midland Gas Managers were able to see last Thursday the shape to which the Company have reduced their project, and the lines on which they mean to carry on their enterprise. The mains have been charged, and some consumers supplied for about a year; and nothing now remains but to increase the steam plant at the generating station to keep pace with the hoped-for increase in the demand. The Company have a commodious site for their station, with good railway facilities for the supply of coal, and a canal for other purposes, including convenience with regard to condensing water. The whole future of the Company is pinned to the realization of the idea that it will pay power users in the town better to purchase compressed air delivered through street mains into their engines than to generate steam for themselves. Consequently the Company have to depend for their profit on the margin they can secure between the cost of generating and distributing power by their machinery and plant and the price which a power user can be induced to pay them for it. In other words, they must solve the problem whether the generation of power in a large station can be done so cheaply, as compared with small engines, that it can be sold at a profit, notwithstanding the loss of distribution by the medium employed for the purpose—in this case compressed air. Consequently a visitor to the works of the Company may reasonably expect to see the most efficient steam power plant that money can buy.

The problems of generation and distribution may be considered, as they have to be solved, separately. A compressed air company may be supposed to fail, if it fails at all, through defective generating plant, or imperfect distributing arrangements; and certainly cannot succeed unless both are perfect. The first necessity is, however, good steam plant. The Birmingham Company propose to employ their capital of £150,000 in generating 6,000-horse power, and supplying it throughout the Birmingham district. Half of the steam plant required is being laid down to begin with, and a portion is actually at work. That seen by the Midland Gas Managers consisted of a triple expansion compound condensing engine, by Fowler, of Leeds, working single-action plunger air pumps feeding directly into the main, and supplied with steam by three sectional water tube boilers, fired with gas made in Wilson producers from slack costing on the spot about 6s. per ton. Nothing could well be more elementary, or, in its way, satisfactory. While the scheme was incubating there were all sorts of refinements talked about—electrical check-meters and several other imaginary requirements. These more or less "cobwebby" additions to the simple steam plant have been quietly dropped, and the works are only a steam power station worked according to gauges and indicators of the ordinary type. The main engines are after the marine type, and are believed to be almost unique in respect of repeating on land the elements that have proved so successful in economizing steam on board ship. Each set will work up to about 1,000-horse power indicated; but at the present time scarcely half this is required. The high-pressure cylinder is supplied with steam at about 140 pounds per square inch, which is reduced to 45 pounds in the second cylinder, and to 3 pounds in the last, which chiefly works by virtue of the vacuum. The air is compressed to 45 pounds per square inch in the mains (there being no accumulator), and this pressure develops at the outset a considerable amount of sensible heat. Theoretically the rise of temperature should be 260° F., but a good deal is very quickly lost; and although the air at its entry into the mains may be at a temperature of 200°, it quickly cools down, depositing water at the same time, so that before it is half a mile from the works, it is at the normal temperature and dry. The duty obtained by the user is about 50 per cent. of the power put into the air at the station; so that of 1,000-horse power generated at the station 500-horse power may be depended upon to re-appear in the consumers' motors, supposing the air to be utilized in this way. There are other applications for the air, of course—such as refrigerating, blowing, etc.—which would in practice complicate the problem of ascertaining what becomes of the power generated at the station. At all events, there is a loss of 50 per cent. of energy, due to the medium of distribution, to be compensated for by increased economy of generating plant as compared with ordinary steam machinery.

The engines must supply their share of this economy; and it is probable that no steam-engines in Birmingham of less than 100-horse power, and very few above, show such economy of steam as those of the Compressed Air Company, which are stated to use only 16 lbs. weight of steam per indicated horse power, and are confidently expected to do even better when they are fully loaded and running at their best speed. Next to the engines come the boilers. These, as already mentioned, are after the sectional water-tube pattern, which seems to be making great headway where high pressure steam is required to be economically produced, to the supersession of the old-fashioned Lancashire boilers. We should like to see some authoritative evidence on this head. There are no means of telling at present how these boilers of the Compressed Air Company compare with the generality of steam generators in the town; but if there is anything in following the fashion, they certainly enjoy it. With regard to the last, and in many ways most important point of this plant—the gas generators—we cannot say that the system adopted shows any conspicuous advantage over any good form of mechanical stoker. The advantage of gasifying the fuel at a distance from the point of utilization, and so losing the radiant power of the solid fuel, as well as that portion of its heating power which escapes during transit through long underground flues, is very doubtful. The idea of employing generators was adopted by the Company's Consulting Engineer (Mr. J. Sturgeon), in order to cope with the conditions of a varying demand on the works. He thought the supply of fuel gas could be checked and increased as required with greater convenience and economy than a direct-acting fire-grate; but whatever may be said for the intention, the Wilson gas producers seem to be scarcely the right things to carry it out. It was stated, among other drawbacks of their use, that they require to be let down cold for clinkering every three days; which must mean a serious loss of heat; and they need constant attention. The success of the Company does not, of course, depend on this or any particular gas producer or mechanical stoker; but they cannot be regarded as in a safe or logical position until they can challenge anybody in the town and district to a comparison of furnace and boiler efficiency.

The Midland Gas Managers had no time to inspect any of the factories where the compressed air power is in use; but they saw, on the works, a small engine driven by it, and heard an account of the uses to which it is applied. There is not much to be said concerning the distribution arrangements. The mains are of wrought iron or steel, without flanges or sockets and spigots; being jointed by means of sleeve-pieces; or double socket rings, leaded on both sides. These make a perfectly tight joint, and there is an expansion joint made with an india-rubber ring at about every twelfth length. The thickness of the pipe is not sufficient to allow services to be tapped in, in the ordinary way; and therefore junctions are provided at intervals, fitted with valves, which allow connections to be made without interfering with the pipe or stopping the service. Consumers are supplied through meters designed, on the principle of the turbine, by Mr. Abrahams, the Resident Engineer, which appear to be more satisfactory in action than anything else of the same kind which the Company have been able to procure.

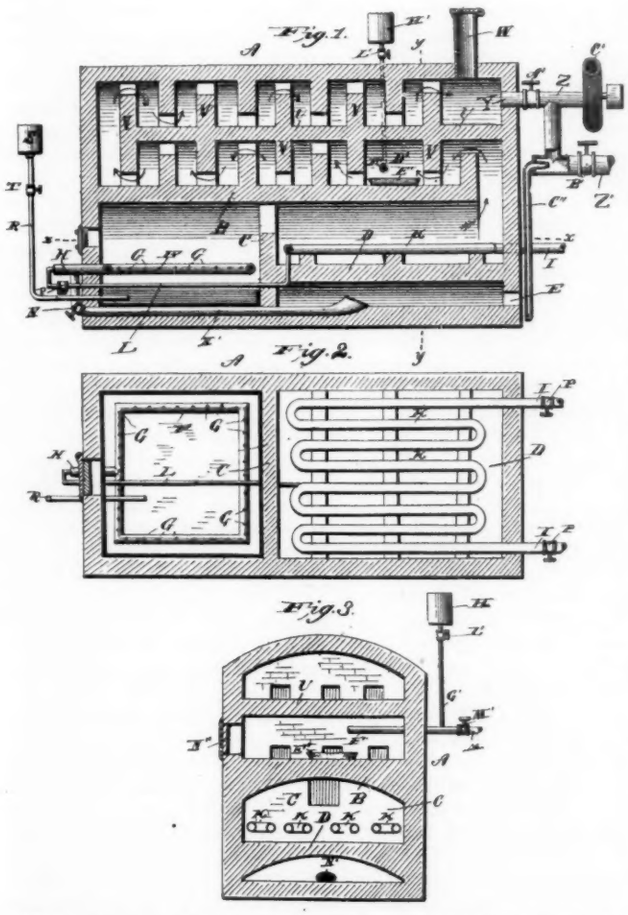
The visitors were received by Mr. Sturgeon, the Consulting Engineer, who attended specially for the purpose, and were shown round the establishment by Mr. Sturgeon and Mr. Abrahams; these gentlemen being most assiduous in their attentions, and untiring in answering queries and giving information. A well-deserved vote of thanks to the Directors and officers of the Company was tendered by the President of the Association, and fittingly responded to. The visitors carried away with them a high appreciation of the thoroughness with which the Compressed Air Company have set themselves to carry out their undertaking, as well as a favorable impression regarding the future which appears to lie before the application of compressed air to industrial and social purposes. The driving of engines in factories by this agency means not only economy in many instances, but also cleanliness, safety, and deliverance from smoke and damp steam. It also means improved ventilation and cooling of crowded workrooms; thus adding to the comfort and conducive to health and happiness of the operatives. Shops, theatres, warerooms, and churches, to say nothing of private houses, can be efficiently ventilated when a supply of compressed air is available; and if the Methven-Sugg system of gas lighting is to flourish any-

where, it should be in Birmingham. It is even possible something altogether fresh may be done in the way of burning gas under pressure of air. Many other uses of the Compressed Air Company's product might be named; but we are not concerned to state the probable extent of their operations. Suffice it to say that their scheme, and the manner in which they are carrying it out, are worthy of the attention of all engineers, especially those who are interested in power distribution.

The Gearing Apparatus for the Manufacture of Gas.

U. S. Letters Patent (No. 414,038) were granted, on October 29, to Charles Gearing, of Pittsburg, Pa., for improvements designed to facilitate the manufacture of gas. From the specifications of the patent we learn that the improvements put forth have for their object the providing of an apparatus consisting, essentially, of a furnace and a generator of peculiar construction, the two being so arranged and connected that the hydrocarbon may be burned in conjunction with air and superheated steam, so as to generate the necessary heat to bring about the decomposition of the gases in the generator and to generate initially a volume of mixed gases to be subsequently decomposed in conjunction with a suitable fluid hydrocarbon to produce the ultimate heating or illuminating gases.

Referring to the cuts, Fig. 1 represents a longitudinal vertical section of an apparatus embodying the invention. Fig. 2 represents a transverse horizontal sectional view taken on the line *x x* of Fig. 1; and Fig. 3 represents a transverse vertical sectional view, taken on the line *y y* of Fig. 1.



At *A* is shown a structure of substantially rectangular shape, which is constructed of brickwork or other suitable material. The said structure is provided with a horizontal partition *B*, which extends from its forward end nearly to its rear, as shown in Fig. 1, and which divides the interior of the structure into two chambers. In the lower chamber is located a transverse bridge-wall or partition *C*, provided with a passage or a series of passages near the top, the said bridge-wall or partition dividing the said lower chamber into two smaller chambers, the forward one of which constitutes the combustion chamber or firebox of the apparatus and the rear chamber a superheater, for the purpose hereinafter described. The latter chamber is subdivided by a horizontal partition *D*, the lower chamber thus formed communicating with the atmosphere by a suitable passage *E* at the rear.

In the combustion chamber, at a suitable distance above the bottom, is located a pipe *F*, which extends around the walls thereof, and is provided with a series of apertures *G* for the ejection of a mixture of steam and air which is injected into said combustion chamber when the apparatus is in operation, as more fully hereinafter explained. Connected with the said pipe is a branch pipe *H*, extending through the forward wall of the firebox or combustion chamber, and with this latter pipe connects an air pipe *N'*, leading from the chamber below the partition *D*, through which a supply of air may be drawn and forced into the pipe *F*.

The letter *I* indicates a steam pipe leading from a suitable generator through the rear wall of the structure into the chamber above the partition *D*, and continued in said chamber in the form of a superheating coil *K*. From the said superheating coil extends a pipe *L* to the forward part of the structure, where it is bent upward and enters the forward end of the branch pipe *H*, terminating therein in a suitable nozzle, forming an injector, by means of which a current of steam is injected into the said pipe *H* and the pipe *F* connected therewith, so as to induce a current of air in conjunction with the steam through said pipes and inject the mixture into the firebox or combustion chamber in proper proportions. The said air and steam pipes are provided with proper valves *N P*, by means of which the quantity of air or steam admitted is regulated.

In the lower part of the firebox or combustion chamber is located an oil pan or receptacle for the fluid hydrocarbon, and through the forward wall of the said combustion chamber or furnace extends a pipe *R*, leading from a hydrocarbon reservoir *S*, through which the hydrocarbon may be supplied to the pan, the flow being regulated by means of a suitable cock or valve *T*.

The upper chamber of the structure *A* is divided by means of a horizontal partition *U* into two chambers, one above the other. The said partition extends from the rear of the structure to near the forward end thereof, as shown in Fig. 1. The said upper and lower chambers are divided into smaller chambers by means of a series of vertical partitions *V*, having passages alternately at the top and bottom, as shown, through which the gases from the superheating chamber pass in the direction of the arrows, Fig. 1.

W indicates an eduction flue leading from the rear of the upper chamber of the furnace, which is provided with a damper or valve *X*, by means of which said flue may be opened or closed at will. From the rear of said upper chamber also extends a pipe *Y*, provided with branches *Z Z'*, leading, respectively, to a service pipe or holder and provided with suitable valves *A' B'*, by means of which the flow of the escaping gas can be regulated. Either or both of these pipes may be provided with an exhaust device *C' C''*, which may consist of an exhaust fan or steam injector, as shown.

The chamber *D'* in the lower generating chamber is provided with a pan *E'*, or has its bottom and walls suitably lined, so as to form a hydrocarbon receptacle, and into said chamber, which is made larger than the other, extends the end of an injector pipe *F'*, connected by a pipe *G'* with a suitable oil reservoir *H'* and by means of a suitable pipe *M* with a steam generator, by means of which a supply of hydrocarbon may be injected into said chamber. The said pipes are provided with suitable valves *L' M'*, by means of which the flow of oil and steam can be regulated.

The letter *N''* indicates a suitable passage leading into the chamber *D'* at one side and provided with a suitable door, whereby access may be had to the chamber when desired for cleaning or other purposes. The forward wall of the combustion chamber is also provided with a similar passage and door for a like purpose.

The operation of the improved apparatus is as follows: Oil or fluid hydrocarbon, being supplied to the pan in the lower part of the combustion chamber through the supplying pipe, is ignited. A supply of steam and air is then injected into said chamber through the steam and air pipes, causing rapid combustion and generating a volume of mixed gases, which pass into the superheating chamber at the rear. From this chamber they pass into the lower generating chamber, entering first the chamber *D'*, where they meet with a jet of oil and steam injected through the pipe *F'*. By this means a mutual decomposition of the gases, steam and fluid hydrocarbon is effected, the resultant gases and vapors passing to the front in the direction of the arrows and then to the rear through the upper chamber in the direction of the arrows shown therein. From the upper chamber the gases are finally passed to the holder or through a suitable main to the point of consumption by means of the branching eduction pipe.

Sir William Siemens's Gas-Aided Domestic Fire.*

By Dr. W. Pole, F.R.S.

In the present strong competition between gas and electric lighting, laudable efforts are being made to extend the use of gas for heating purposes; and among these its application to the domestic fireplace has been attempted on a somewhat extended scale. The usual plan is to abolish the ordinary fire-grate and to substitute a special apparatus in which jets of coal gas mixed with air are allowed to play on pieces of asbestos or pumice stone, which after a time become heated, and so radiate off heat into the room.

About 1880, the late Sir William Siemens, whose name is so eminent from his wonderful heat inventions, took up the subject as one of great public interest, and I am surprised that more attention has not been given to the valuable improvements he proposed. These were first described by him in an article in *Nature*, Nov. 18, 1880, having the title of "A New Cure for Smoke." In his later years he was constantly urging the use of gaseous fuel, and after describing the advantages he had realized with it in manufactures, he says:

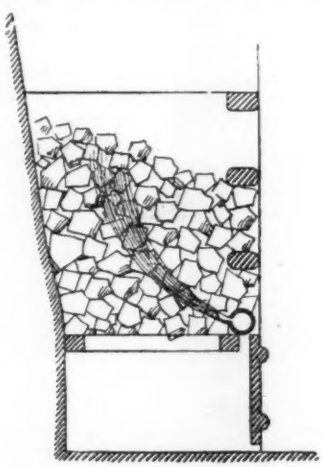
"There seems no *a priori* reason why analogous results should not attend its application on a smaller scale, even down to the means of heating our apartments, which, although a small application in each individual instance, amounts, in the aggregate, to the largest of all the uses of mineral fuel."

He had, of course, studied the "gas fires" above alluded to, but he remarked that they were very expensive, both in construction and in gas consumption; gave insufficient warmth; were cheerless in appearance; produced heat of an unpleasant character; and often gave out disagreeable smells.

His thoroughly practical mind and great experience led him to go upon a different tack. He saw that a far more likely plan to succeed was to retain the general plan of the ordinary fireplace and fuel, but to bring in gas as an adjunct to it; and he accordingly devised a plan for this purpose.

It should be explained that at that time the "smoke abatement" movement was active, and, as the title of his paper showed, he made his invention conform to that object. He proposed to construct a grate in which jets of ordinary coal gas should play among coke, the combustion of the two going on together, and being supplied by a peculiar contrivance with heated air. Thus was formed a smokeless fire of great heating power. Many were made under the inventor's direction which answered perfectly, and it is strange that some enterprising manufacturer has not thought it worth while to promote their sale.

My object, however, now is to call attention to a somewhat simplified form of the invention. The hot-air provision requires an entire reconstruction of the lower part of the fire-grate. This is rather expensive,



and good housewives object to the mess and trouble of such changes. Moreover, the arrangement offers some obstruction to the free removal of the incombustible residue of ash, which with ordinary gas coke is sometimes very considerable, and the retention of which impedes the combustion and spoils the brightness of the fire.

The simplified plan leaves the grate exactly in its original state, just as made for an ordinary fire. Then all that is to be done is to put at the front of the grate, between the two bottom bars, a piece of iron gas tubing pierced with a few holes pointing obliquely upward, so as to throw, when supplied with gas, jets of flame into the body of the fire.*

This is an exceedingly simple thing, and if gas is already laid on in the room a gasfitter may do it in a few hours, and for a few shillings, without making any mess or giving any trouble whatever. The holes may be about the size of a knitting needle, and about 1½ inches apart. And there must, of course, be a cock placed in an accessible position to turn the gas on or off, or to regulate it at pleasure.

This is "Siemens's gas aided domestic fire," for it is really in every respect an ordinary fire, only with the power of aiding it when desired by Siemens's gas flames.

Now let us see what this aid is worth:

1. In the first place it enables coke to be used. This is a better fuel in many respects than raw coal; it makes a steadier, more compact, and more enduring fire, and gives out no smoke or soot. It is difficult to keep coke alive in an ordinary grate, unless the burning mass is large and the draught powerful; but with the addition of the gas it burns perfectly, in any quantity, and in fact, as is well known, the gas resupplies to the coke the hydrocarbons which had been abstracted in the gas works, and so restores the original elements of the fuel, but in an improved and refined form.

I have found, however, that it is advantageous to have a small supply of coal to use in addition to the coke, by which the use of the gas may be much lessened, and, indeed, often stopped altogether; as the mixed fuel will make an excellent, pleasant and economical fire without it. A little experience will soon give instruction on this point. It is worthy of notice that the coal when burnt in combination with the coke and the gas makes much less smoke than when alone. This is easily accounted for. The cause of the production of so much smoke from the coal in an ordinary grate is the low temperature at which its decomposition is effected; here the particles of coal are enveloped in hotter surroundings, and the combustion is more complete.

2. The reduction of smoke from the fire is not only an infinitesimal contribution to the general "Smoke Abatement" movement, but it is an advantage to the householder himself. It diminishes the spread of dirt in the room (for it is seldom that all the products of the fire go perfectly up the chimney), and it either abolishes, or at least much lessens, the frequency of the great nuisance of chimney sweeping.

3. The gas gives the facility of lighting the fire at any moment without the usual "laying" of wood and paper. This laying is ordinarily an enormous domestic trouble, involving the previous emptying and cleaning of the grate; and it is often most annoying, when a fire is unexpectedly wanted, to have to wait while the operation is being performed. It is often a chance, too, whether the fire will ignite or not, and if it does not, it has to be laid over again. But with the gas nothing need be done but to put fuel in the grate and turn on the gas, when the lighting of the fire is speedy and certain. A very common case when this power proves of great advantage is when a little fire is desired in a bedroom on going to bed at night, and again on getting up in the morning. After the night's use the ordinary fire must be "laid" again before it can be lighted the next day, which is so great a trouble as usually to forbid the practicability of the arrangement, but with the gas addition nothing can be easier.

4. With this plan a fire never need go out; a little of the gas aid will suffice to check this proverbial natural tendency, and the fuel will go on burning till exhausted, and even then the gas will keep the grate warm. Hence stirring or poking the fire becomes a work of supererogation, or at least is only wanted at long intervals to help the exit of the dead ashes through the bottom grating.

5. With this arrangement the grate need never be emptied, except occasionally for housewifely cleaning. With the ordinary fire it is customary to empty the grate before every new laying, when a great deal of valuable fuel in the shape of cinders goes to the dust hole. With the gas arrangement all that is necessary is to rake out the incombustible white ash, leaving the carbonaceous cinders behind to be burnt with the new fuel. This is a great source of economy.

6. The gas gives altogether a new power over the fire—namely, that of its regulation according to what is wanted. This, with an ordinary fire, is impossible, except in a very imperfect and extravagant way, but only experience can give an idea what an admirable and delicate power of adjustment is given by the little gas tap. It is not so much the gas itself that is regulated as the influence of the gas upon the fuel. It acts as a sort of blow-pipe; when full on the combustion is highly active, but the stimulus can be lowered to any extent or entirely withdrawn. The combined use of coal and coke greatly facilitates this power of regula-

*London *Builder*.

*It would be an improvement to sink the tube below the bottom of the grate, but this would require some reconstruction.

tion. If this fire is required to be steady for a considerable time a judicious mixture of the two fuels, with just a *soupcon* of the gas to prevent any tendency to go out, will give a far steadier and more durable fire than the ordinary one; but if it is wanted only for a short time, and then to be lowered, it should be chiefly coke and gas, which will be more sensitive. Suppose, for example, the case where a room has to be left for some hours, the fire not being wanted; the gas can be turned so low that the fuel will scarcely consume at all; but still will remain so hot that on coming to the room again and simply turning on the tap, in a few minutes the fire will be fully restored.

For bedrooms in cold nights, and most especially in cases of sickness, such a convenience is invaluable. A low fire, burning steadily all night, with a kettle of water on the hob or the trivet, would often be found a great blessing. And there are numberless other cases where a small fire which will burn for a long time without attention and without danger of extinction would be most desirable. This cannot be obtained at all under the ordinary *regime*, but with the Siemens arrangement it is the simplest thing possible.

7. But we may go further. The gas arrangement may be made of great use even without the fire. In winter, when several fires are burning, and doors and windows are closed, the whole atmosphere of the house becomes subjected, by the action of the fires, to a slight exhaustion, and every chimney where there is no fire is liable to have a downdraught into its room, bringing with it dirt, foul air, and smells from adjoining chimneys. The usual remedy is to "shut the register," if there is one; but this is only an imperfect provision, as it is never anywhere near tight. In this case a slight use of the gas alone will keep a proper current up its own chimney, and will give a gentle warmth in the room, at very little cost, and no trouble to anybody.

8. Then even in summer, the gas is still useful. Everybody knows that a chimney is the ordinary and often the only ventilator for rooms; but in summer when there is no fire, the chimney, having no motive power to give it a current, does not act. In this case, as in the last mentioned, the gas may be used to give a current up the chimney, a screen being provided and hung on the front of the grate, like a fire-guard, to prevent the heat radiating into the room. This arrangement accompanied by a window open an inch or two at the top, will ensure a gentle but most healthy change of air being constantly kept up in the apartment night and day. Moreover, the gas is then at hand, always ready for any accidental heating purpose that may be required.

9. It seems to me (though perhaps it may be thought a rather fanciful idea) that a fire which has all these capabilities becomes an object better worth intelligent care and attention than formerly. An ordinary fire is considered a rough, coarse thing, only fit to be left to the clumsy treatment of footmen and housemaids, except when the authorities may choose to amuse themselves by poking it (either from the bottom or top, as the sex may determine). But in this contrivance there is really something interesting to observe, and something intellectual to do; which will well repay a little thought and skill; while, at the same time, there is no compulsion in the matter, and if it is not done the house is no worse off than before.

It will naturally be asked at what cost all these advantages can be gained? As already stated, the outlay for the construction is exceedingly small. There is only a word or two to be added about the current expenditure. In the first place this must naturally be much less than for the asbestos or pumice-stone "gas fire," in which the whole heat must be furnished by the gas; seeing that in the plan here recommended the coal and coke form the efficient fuel, to which the gas is only a subsidiary aid. I find that in a grate I have, of moderate size, the six jets when blazing fully on will consume about 20 cubic feet of gas per hour; but this is only exceptionally necessary, to light or quickly to strengthen the fire; the gas is often shut off entirely, and we may estimate say 10 feet as an ample average; this will cost in London about one-third of a penny per hour.

I do not think that this would be a very high price to pay for the advantages named; but it must be recollected that there is a large set-off to be made for savings. In the first place, there is the use to a large extent of coke, which is more economical than coal; and then there is much economy in the saving of cinders; in the easy regulation of the fire, according to demands, particularly by keeping it low; and, still more, in the power of extinguishing it when not wanted, with the option of lighting it again at a minute's notice. These savings cannot be put in definite money value, but they will certainly reduce materially, if not cancel entirely, the cost of the gas.

Some people have thought that the small holes would soon be stopped up by fine ash. Experience negatives this fear, and it would seem that generally the current of gas through them suffices to keep them fairly open. It is, however, desirable to have a bent pricker at any moment; and the tube itself should be connected by a screw, so that it may be taken off occasionally to be cleaned, or may be renewed when burnt or worn away.

To sum up:

The addition of the gas aid to a fire gives many great advantages for comfort, convenience, and usefulness in domestic economy. It is no patent, no monopoly; it requires no new grate, but only a small addition to the ordinary one, which any good gasfitter can fix quickly and at small expense.

It does not interfere with the use of the grate in the ordinary way.

The increased expenditure for gas is very small, and is largely compensated for by increased economy of fuel in many ways.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

THE Consolidated Telegraph and Electric Construction Company, of this city, has determined upon the following rentals for the subways constructed under its auspices: For the use of one mile of 2-inch pipe, $750 per annum; one mile of 2½-inch pipe, $850 per annum; one mile of 3-inch pipe, $1,000 per annum. In 1897 the subways are to become city property, the Construction Company to receive 10 per cent. over the cost of construction. Take it all in all, this Company seems to have secured a very productive franchise, and some of its provisions are not unlike those that Branham, Hardesty & Co. are anxious to obtain from the city of St. Louis in respect to that proposed municipal gas works franchise.

A CORRESPONDENT, writing under date of the 2d inst., says: "Yesterday was the 25th anniversary of Treasurer Joseph L. Hallett's connection with the Springfield (Mass.) Gas Light Company; and to celebrate it fitly as well as the 41st anniversary of the Company's existence, Mr. Hallett gave a pleasant dinner to the Directors and Clerks, at the Massasoit House, on Thursday evening. The occasion was entirely informal. Everyone had a good time, and there were plenty of reminiscences of the good old times, remarks being made by Mr. Wm. N. Hale, President of the Company, James A. Rumrill, Henry S. Lee, Elisha Gunn, Dr. Corcoran, Samuel W. Porter and Marvin Chapin, who was President of the Company for 13 years, and is the oldest Director, having been on the Board since 1856. When the Company was organized in 1848 it was with an original capital of $15,000. When Mr. Hallett joined the Company, in 1864, it had 927 consumers on its rolls, and an annual output of 30,000,000 cubic feet of gas. Now there are 3,300 consumers, and the output has increased to 82,000,000 cubic feet. While the increase of population during the 25 years has not been over 100 per cent., the growth of progressive ideas is shown by the fact that the increase in the gas output has been 170 per cent. The original Board of Directors, as recalled among the other reminiscences of the banquet, were among the most prominent men in the city, the list including Chester W. Chapin, Geo. Dwight, Jas. Brewer, Jas. Barnes, Jas. D. Brewer, Henry Gray, Solyman Merrick and Addison Ware. The future prospects of the Company were also discussed, and all agreed that the outlook was very bright. The gas mains are being constantly extended, and even with the electric light as a competitor, business never was better. Treasurer Hallett, despite his seeming languidness, is about as brisk a man as there is in our beautiful city, and the soundness of his business views is pretty well exemplified in the clever way in which the affairs of the Springfield Company have been managed since he was put in charge of the helm."

WE understand that the proprietors of the Macon (Ga.) Consolidated gas works have closed negotiations with Mr. Nussbaum for the local Brush Electric Light system formerly under control of the latter, and from which the city's public arc lighting is to be supplied, under the contract awarded to Nussbaum some weeks ago.

THE City Clerk of Appleton, Wis., has notified Messrs. Edward D. Comings and Charles C. Housell (the indorsement of whose application for the right to operate a fuel gas plant in that city was recently made by the Councilmen), that the city expects them to begin construction work forthwith. While the grantees assert that they intend to go right ahead under the agreement, we incline to the view that such a plant will not be constructed in Appleton for some time yet.

IN the meantime it might be well to note that on or about October 30th a deed was recorded in the office of the Register by virtue of which H. G. Freeman, as Trustee of the old Appleton Gas Light Company, in

consideration of $17,500, conveys the entire plant and everything appertaining thereto to Mr. J. P. Buck, and to Mrs. L. W. L. Goff, as guardian of Louis W. Lyon.

THE Baltimore papers of late date report the death of John J. Bujac, who, at the last session of the Maryland Legislature, attempted to have a bill passed for the establishment of a municipal gas works for Baltimore. Bujac claimed to have discovered a method of gas making whereunder the supply of gas in large cities could be carried on at a profit at a charge of 25 cents per 1,000; and he will also be remembered from his "expert" testimony delivered at one of the sessions of the Spooner Committee that was some time ago, on behalf of the United States Senate, "investigating" the manufacture and supply of gas in Washington, D. C.

THE New York syndicate, headed by Mr. Fanshawe, have acquired the property and franchises of the San Diego (Cal.) Gas Light Company, and will expend a large sum of money in plant betterments. Notable among the improvements will be the putting down of 15 or 20 miles of street mains—an extension that is sadly needed.

MR. W. K. MURPHY is arranging with contractors for the construction of the water and light plants for Murphysboro, Ills. It is probable that the gas works division of this enterprise will not be taken up until next spring. The water plant and the electric light works, however, will be installed as soon as possible.

THE Philadelphia *Inquirer* calls attention to the fact that the Goodwin Gas Stove and Meter Company have just shipped to Chicago a very large consignment of their goods. The value of the same was in excess of $8,000, and comprised 8 immense sun dial gas ranges, the combined length of which is over 57 feet; 3 gas boilers, weighing 800 lbs. each; 2 toasters and 3 bake ovens. They are for the immense Auditorium Hotel, in Chicago, which has 2,000 rooms, and which is to be one of the greatest hostelries in the world. The kitchen of the hotel is to be on the tenth floor, which it will entirely occupy, and *every bit of the cooking is to be done by gas.*

THE residents of Chattanooga, Tenn., are complaining bitterly over the quality of the illumination supplied by the local electric light company.

AFTER his return from the East, President Emerson McMillin, of the Laclede Gas Light Company, was interviewed by a reporter of the St. Louis *Republic*. In the course of his remarks, Mr. McMillin said: "I do not believe anything new has developed in gas matters during my absence, except, possibly, the call for a meeting of the stockholders of the St. Louis Gas Light Company, to be held November 7th. I should imagine the object of such a meeting is to discuss the situation, give every one a chance to express his views, and possibly to decide upon some line of action to be taken in winding up the affairs of that Company. Its franchise from the city expires January 1, 1890, and as the regular annual meeting of the Company takes place in December, the dates are almost too close together to permit of delaying a conference as to the action of the outstanding stockholders until that time, and I suppose this meeting of November 7th was called accordingly. I do not know whether it will be definite in its results, and am inclined to believe it will not. I notice an ordinance has been introduced in the Council asking that the city be authorized to dispose of 199 shares of the St. Louis Gas Light Company stock. The city holds 200 shares of that stock, and it strikes me as being an awkward provision that named 199 shares as the limit to be sold. There has been no change in the price of the stock that would cause the city to come in on any better terms than any of the other St. Louis Company's stockholders who have already entered into the arrangement with the Laclede. If the city has decided to sell it will be at the price already fixed, viz.: $375 per share, either in cash or Laclede stock. Yes, I have followed all the recent experiments in cheap fuel, cheap gas, etc. There is nothing new in them, and we have reports of these discoveries of marvellously cheap methods of manufacturing gas every week. All I can say is, don't waste ink on them. As a gas engineer I have thoroughly studied and experimented on this subject, and have yet to see anything of practical value developed by any of the processes."

MESSRS. REED and Campbell, of Norwich, N. Y., are installing a test plant in that village for the purpose of practically determining the merits of the Knapp process for the manufacture of heating and illuminating gas.

A CORRESPONDENT writes: "The Yonkers (N. Y.) Gas Light Company has recently constructed a building for purifying purposes on the wharf at the foot of Ashburton avenue. The new building is 56 feet square, 25 feet in height, with a slate roof, and makes a handsome appearance. It was built under the direction of Isaac N. Knapp, one of the Company's constructing engineers, who sublet the brickwork to Geo. U. Stewart, and the roof and carpentering work to Edward F. Eggleston. The cost was about $10,000. The purifying apparatus proper, which cost $15,000, will have a capacity of 1,500,000 cubic feet per day, although the Company's output now is only one-half million per day. The apparatus will consist of 4 purifying sets, 20 feet square and 3 feet deep, connected with the holders on Woodworth avenue by a 16-inch pipe. Hydraulic elevators have also been provided. The apparatus and iron work were made by Messrs. Bartlett, Hayward & Co., of Baltimore, Md., and the specials were furnished by Messrs. R. D. Wood & Co., of Philadelphia. The apparatus now but awaits the reception of the trays—of the Cabot type—and will certainly be in duty by the middle of the month. This all involved a large expense, but the proprietors of the Company have ever shown a disposition to keep up with the times. I must also remark that the output of gas in this city is constantly in the ascending scale.—M. A."

MR. GEORGE M. ROSSMAN, the popular Superintendent of the Keene (N. H.) Gas Light Company, is no longer a bachelor, having taken unto himself a helpmeet in the person of Miss Minnie F. Derby, the charming daughter of Mr. Albert Derby, of Bellows Falls. May happiness attend them.

THE City Council of Pierre, Dakota, has awarded a franchise for the operation of a gas works at that point to Mr. Thomas Bixby, of St. Paul, Minn. The franchise is to be exclusive for 20 years, and the grantee has agreed to have the plant in operation by March first.

AT the meeting of the incorporators of the Winnepiseogee (N. H.) Gas and Electric Light Company, held at Laconia about a fortnight ago, the Directors elected were Messrs. Jno. C. Moulton, Frank B. Holt, Frank H. Longee, Frank E. Busiel, S. B. Smith, Jno. S. Crane, B. F. Drake, H. J. Odell, G. H. Robie, H. W. Burget and W. L. Melcher.

THE 232 shares of the Homer & Cortland (N. Y.) Gas Company's stock, which we noted some time ago were to be sold at auction, were knocked down to the bid of Arthur S. Kennedy, of Cortland, at the figure of $28 per share. There was quite a competition for the lot.

ONE of the ridiculously unfair provisions of the Civil Code of San Francisco, Cal., is Article 15, Section 629, which is as follows:

"Upon the application in writing of the owner or occupant of any building or premises not more than 100 feet from any main of the corporation (meaning gas company) and payment by the applicant of all money due from him, the corporation must supply gas as required for such building or premises, and cannot refuse on the ground of any indebtedness of any former owner or occupant thereof, unless the occupant has undertaken to pay for the same. If, for the space of 10 days after such application, the corporation refuses or neglects to supply the gas required, it must pay to the applicant the sum of $50 as liquidated damages, and $5 a day as liquidated damages for every day such refusal or neglect continues thereafter."

THE death of Mr. F. M. Roots will in no way disturb the continuance of the business of the firm of P. H. & F. M. Roots.

IT is reported from Philadelphia that the plant of the Germantown Electric Light Company has been purchased by Mr. Wm. G. Warden and other well known Germantown capitalists. The capital stock is to be increased to $200,000, and it is the purpose of the present proprietors to erect a new station at Armat and Cumberland streets; also to install an incandescent plant, rated to maintain 20,000 16-candle lamps.

THE likely final law chapter in the opposition gas movement at Elizabeth, N. J., was initiated on October 31, on which date Vice-Chancellor Van Vleet was occupied in listening to arguments on the application of counsel for the Elizabeth Gas Light Company for an injunction restraining the Metropolitan Gas Company, same city, from laying pipes through the streets. Ex-Chancellor Runyon, Ex-Judge F. W. Stevens and R. R. Lindebury appeared for petitioners, and James R. English for remonstrants. Plaintiff bases its prayer on the ground that the charter of the Metropolitan Gas Company was granted by the Legislature some 19 years ago, that the provisions of the law have not been complied with by the stockholders in respect to annual elections for officers, and that in

consequence the charter has lapsed. Those who are in a position to know assert that the injunction proceedings are not tenable.

THE Peoria (Ills.) Heating, Power and Gas Light Company has been incorporated by Messrs. Irving W. Johnson, Jno. H. Francis and S. A. Kinsey. Capitalized in $500,000.

ARTICLES incorporating the Albany (Oregon) Canal, Water, Transportation and Lighting Company have been filed by C. C. Hogue, A. Bensell, J. O. Wilson and J. S. Ripley. The capital stock is put at $300,000. One branch of the enterprise is the construction of gas and electric light works at Albany. Among those interested we note the name of Col. T. E. Hogue, President of the Oregon Pacific Railroad Company.

IN respect to the threatened strike by the employees of the Boston Gas Company, "Observer" writes that it is likely the men will not go out, but will submit to arbitration. The Company, he adds, has managed this troublesome affair in a truly admirable manner.

THE syndicate that has purchased the Mendota (Ills.) gas works, formerly owned by Judge Foley, of Lincoln, Ills., also controls the fortunes of the Mendota Electric Light Company. The names of its members are: M. A. McKey (President of the Electric Company), Geo. Price, L. R. Curtiss, D. Rude and J. D. Tower. The purchase was made because the contest for business had assumed a very bad phase for the electricians, and truth compels the admission that the Gas Company was not growing rapidly rich either. The latter, however, had the better of it. The schedule of rates for gas adopted by the present proprietors (to take effect on 1st inst.) was placed at the following:

Monthly Consumption.		Net Rate per 1,000.
Not exceeeding 1,000 cu. ft.	.....	$2.00
1,100 to 5,000	"	1.75
Over 5,000	"	1.50

These are very fair, and show that the Company is in the control of progressive men. Mr. L. P. Gerould is to act as Superintendent, while Mr. L. R. Curtiss will hold the position of Manager. Contractors might do well to bear in mind that the Mendota plant will in all probability be virtually rebuilt next spring.

THE improvements on the plant of the Freehold (N. J.) Gas Light Company have been completed.

THE Brooks Process Gas Company has purchased the plant of the Gas Company at Hollidaysburg, Pa. The new proprietors have chosen the following officers: President, Henry W. Brooks; Treasurer, Edward Sellers; Secretary, A. S. Landis. The officers and Messrs. A. M. Lloyd, J. W. Snyder and Geo. Torrence compose the Board of Directors.

WE are indebted to Mr. F. R. Persons for the following account of the funeral services over the remains of the late Mr. E. J. King, of Jacksonville, Ills.: "One of the saddest sights ever witnessed in Jacksonville was looked upon by the throng of citizens who assembled on Tuesday morning, 29th ult., to see the dread drama which death has recently wrought by the removal from our midst of two of Jacksonville's noblest men—E. J. King and Dr. Charles Easter. At 10 o'clock the bell in the Trinity Episcopal Church tower began to toll as the two funeral corteges commenced their slow movement from the homes to the church, which was filled to the doors by the friends of the deceased, and by many of the foremost men of the city, who held them in high regard. The funeral party was met at the entrance of the church by the rector, Mr. J. M. C. Fulton, who preceded it up the aisle, reciting in measured tone a collect for the dead, while at the organ Prof. J. H. Davis played a solemn voluntary. Dr. H. Lee Hatch, F. M. Doan, J. A. Bellatti, E. L. McDonald, S. Allen Fairbanks and John G. Loomis bore the casket which contained the remains of Mr. King, while J. W. Chambers, H. Doan, Dr. Fred. Metcalf, Dr. Carl Black, Chas. Catlin, and J. E. Chambers carried that in which lay Dr. Easter's corpse. The caskets, which were of black velvet with silver mountings, were covered with a profusion of flowers. Following the bearers came a long line of relatives and friends. The employees of the Gas Company, in a body, followed the bier of their beloved employer. Reaching the chancel rail the clergyman ascended and facing the audience began the stately and solemn but sympathetic service for the dead. After the opening responsive reading came that grand chapter from Corinthians which illustrates death and the triumph of the resurrection, the choir (quartette) sang the beautiful hymn, 'The Lord shall give His people the blessing of peace.' The remarks of Dr. Fulton were not many but were grandly impressive. Following the Doctor's remarks the choir sang and the people joined in a recitation of the Apostles' creed, upon the conclusion of which Dr. Fulton pronounced a most eloquent benediction. The bearers again lifted their burdens and slowly retraced their steps to the door, while the organist flooded the building with the notes of melancholy's offering. The funeral cortege proceeded on to Diamond Grove Cemetery, where the interment took place. The usual burial service after the ritual of the Episcopal Church was said at the grave, and the quartette sang 'Nearer, my God, to Thee,' and 'Lead, Kindly Light!' The funeral was one of the most largely attended that has occurred in Jacksonville for years."

THE new gas plant at Rockville, Conn., was fired up for the first time on the first inst.

THE Lockwood Company, of Waterville, Me., the gas works annex to which was badly injured by an explosion not long ago, will at once rebuild. The damage was confined chiefly to the building, the generating apparatus being comparatively unharmed.

ACCORDING to the Boston *Post*, Mr. J. E. Addicks is busily engaged at the present time in securing subscribers to the stock of the Loomis Gas Machinery Company, of Connecticut. Our authority further says that the capital of this Company is $10,000,000, of which $6,000,000 has already been issued to pay for the United States patents issued to Mr. Loomis for the manufacture of fuel and illuminating gas. It is now proposed to issue for cash, at a certain price, the balance of the capital stock.

THE special committee of the Boston City Council, appointed to investigate the methods of gas manufacture followed by the Boston Company, at its Prince street plant, have handed in a delightfully vague report. The presentment is against the Company, of course, and we believe the purifying system gave the committee the greatest amount of uneasiness. In any event an order was passed by the Council that the Board of Health be instructed to cause the necessary steps to be taken for the "improvement" of the aforesaid defective system.

THE stockholders of the Concord (N. H.) Gas Light Company, by invitation of its officers, made an inspection of that plant about a fortnight ago. During the year the Company has greatly enlarged and improved its works, an expenditure in round numbers of $50,000 being incurred in completing the betterments. A large gasholder (capacity 125,000 cubic feet) has been erected, and a commodious brick structure, to be devoted to the uses of an exhauster house and workshop, was also put up. The stockholders, not a few of whom on this occasion looked over their property for the first time, were very much interested in the various pieces of apparatus, and all agreed that gas making was a much more complicated operation than they had hitherto thought it to be. Hon. John Kimball, President of the Company, Hon. E. H. Woodman, Treasurer, and Hon. Jno. M. Hill, its former Treasurer and Manager, accompanied the party on their tour of inspection.

A DESPATCH was published in the New York papers of the 3d inst., to the effect that a syndicate of Eastern capitalists, represented by Henry B. Wilson, of this city, has purchased the plant and franchise of the Columbus Gas Light and Coke Company, of Columbus, Ohio. It is said that 95 per cent. of the stock had been secured at a figure in excess of 138. We have no authentic advices, however, concerning the trade.

THE following is from the Philadelphia *Press*, of October 29; "Councils Committee on Gas, at the invitation of the special committee, of which Councilman Yarrow is Chairman, yesterday witnessed a working exhibition of the manufacture of illuminating gas under the Toraya process at the works of the Toraya Patent Gas Company, No. 2200 North 13th street. The Councilmen present were: Select Councilmen Monroe, Snyder, Harris, Freeman and Graham, and Common Councilmen Yarrow, Wilde, Horrocks, Henderson, Stratton, Ford, Heins, Hartranft, Straub, Bardsley, Horr, Edwards and others. At 4.30 P. M., two cast iron cartridges, containing in all 284 pounds of pine wood, were placed in the retorts and remained there until 7 o'clock. In addition to the wood 6½ gallons of crude petroleum were used in other retorts. With 284 pounds of wood and 6½ gallons of oil, 3,355 feet of gas, 69 pounds of charcoal and 8 gallons of wood acid were produced. The gas was lighted and tested, and was pronounced by a number of the Councilmen as the best and brightest they had ever seen. The superior qualities claimed for this wood gas are that it is the cheapest and the most brilliant manufactured. One of the reasons given for its cheapness is that the charcoal and acid produced, when sold,

realize a sum sufficient to materially assist in decreasing the cost. The charcoal is worth about one-half a cent a pound, and the acid can readily be sold for 2½ cents per gallon, so that the product from 284 pounds of pine wood and 6¼ gallons of petroleum would bring at least 54½ cents, materially decreasing the real price of the manufacture. The Company also claims that the gas will not condense, and Prof. Lemuel Stephens, of Girard College, who tested it at the suggestion of Chief Engineer Park, of the Bureau of Gas, reported to the Chief that he "subjected" it to a temperature of nine degrees below zero, by the regular process, discovering no condensation whatever. The light, he said, was 30-candle power. The sub-committee, which has under consideration the offer of the Company to furnish gas to the city, in the meter, at 45 cents per 1,000 feet, has decided upon a favorable report, but wanted the general committee to visit the works before submitting a report. The impression yesterday seemed to be that the general committee would endorse the action of the sub-committee and report the matter favorably to Councils."

A REFERENCE to our advertising pages will show that the Rappleye Governor Burner finds favor among the gas men.

THE certificate of incorporation of the Empire Gas and Electric Light Company, of Suffolk county, N. Y., has been filed. This Company is the one which proposes to operate in Huntington, L. I. It is capitalized in $200,000, and its Directors are: George Olney, Henry L. Van Syckle and Charles A. Godley.

The Illuminating Power of Arc Lamps.

The *Gas World* says that in Berlin the civic authorities, in specifying their requirements in respect to the electric light, stipulated that the arc lamps to be supplied in the street known as "Unter den Linden" should be run with a current of 12 amperes intensity, and give a light of 2,000, or, in some cases, of 5,000 candles. Herr Elster considerably startled all parties interested, and gave rise to an animated discussion, by affirming that the actual lamps did not, in point of fact, give light exceeding 500 candles, and that this materially affected the price of light produced by electricity. The General Electric Company of Berlin instituted a series of experiments in the electro-technical laboratory of the High School of Berlin, under Professor Slaby; and, on the results of these experiments, Dr. Wedding gave a lecture, which itself gave rise to a good deal of discussion. He asks, after considering the recent development of the demand for intense light, what is the meaning of the expression, "a 2,000-candle arc lamp"; is it with or without a globe; is it at any given angle, or is an average intensity?

The first difficulty in the researsch conducted in the High School was that which never fails to present itself, the imperfection of photometrical methods. Physicists care little about practical photometry, and technicians know little about the necessary precautions; consequently, there are, even yet, very few photometrical observations on arc lamps of even moderate exactitude. The Imperial Physical Institute is expected soon to publish some authoritative information on this subject.

Measurement of light in one direction is, with an arc lamp, not sufficient; the intensity varies according to the direction; and measurements must run through at least 90°, from a horizontal direction to one vertically downwards; or, for a closed room, through 180°, from vertically above to vertically below the lamp. All the measurements hitherto made at various angles have been made with the aid of mirrors—measurements made on various lamps at the Munich Electrical Exhibition, 1882; further measurements by Herr v. Hefner-Alteneck at Siemens and Halske's works, as also on absorption by lamp shade; experiments at the Vienna Electrical exhibition, 1883, and by the Franklin Institute of Philadelphia on various lamps and various carbons—and in all these cases the use of mirrors involved a knowledge of the percentages of reflection at the different angles.

Dr. Wedding's experiments were on one of the Unter den Linden lamps, a Siemens's differential lamp. The current supplied, as regulated by the General Electric Company, was 14 to 15 amperes × 48 to 52 volts, produced by a Schuckert's compound dynamo worked by the gas engine of the laboratory.

The rooms were high; and the intensities in various directions were thus measured directly, without mirrors; the photometer used was Elster's modification of Bunsen's. The carbons very rarely burn evenly; then the two sides are not equally illuminated; by using two photometers, one on each side, the average intensity may be found and recorded. The candle unit adopted is the German candle, trimmed so as to burn with a flame 1.8 inch (not 2.0 inches) high; this nearly coincides with the English candle standard. The intermediate light chosen was produced by Albert gas burners; any difference of color (one side of the photometer disc red, the other side blue) becomes, after some hundreds of observations, insignificant to the experienced eye.

The intensity in a horizontal direction is very small (without globe, average 196 candles); it rapidly increases till about 20° (about 1,150 candles) and then more slowly increases, attaining a maximum (about 2,014 candles) at about 42°, and then begins to sink rapidly; at about 60° there is no light, but shadow. The average intensity over the illuminated area is, without globes, about 1,228 candles. With globes the photometric work is much more difficult than without them. With three given globes, the average intensities were:

	Horizontal.	Maximum.	Average intensity.
Globe I	419	970	710
" II	519	1,093	777
" III	497	715	590

The horizontal light is absolutely greater with a globe. On the whole the loss ranges from 40 to 53 per cent.; and this may be diminished, by the use of a reflector, to a loss of about 32 per cent. Tracing out, in the street lighting, the illumination of various points at a height somewhat less than that of a man's head, a series of curves is obtained which show that, with the average data given by the above measurements, and with the lamps at 26 feet 8 inches above ground, the light necessary for reading (= 10 candles at 40 inches) is obtained for a distance of 53 feet from the lamps. The lamps are 137 feet apart. In the intervals the light sinks to 4½ candles at 40 inches. With Wenham lamps Dr. Wedding finds a range of 51.7 candles horizontal to 94 at 45°, and 113.8 at 90°; the average being 95.8; the consumption of gas was 410 liters, or 14.48 cubic feet per hour; but with lamps of this size he finds that the brightness necessary for reading does not extend (if the lamps be at the height of 15 feet 8 inches, and at a mutual distance of 80 feet, and the breadth of the street 50 feet) to a greater distance than 4 feet on each side of the lamp; that it rapidly falls to 2½ candles at 40 inches; and then more slowly to 1.3.

Dr. Wedding thus finds the actual lighting power of the Siemens differential arc lamp, as used in Berlin, with the globe on, to range from 510 candles directly downwards to 1,183 in a downward direction inclined 40° to the horizon, and 640 at a downward slope of 5°. Dr. Wedding had the lamps clean and bright in the laboratory. His broad result is that with the most transparent of the globes supplied him, and with freshly whitened reflectors, the average lighting power was 834 candles. Herr Elster, in actual street measurements, obtained an ultimate average of 641 candles; his earlier results were below this, being about 500 candles.

The Berlin authorities, it has been observed, stipulated that the lamps should give 2,000 candles with 12 amperes; they each give 650 candles in the street to 850 in the laboratory, with 14 to 15 amperes and 48 to 52 volts; or, as nearly as possible, 1-horse power of actual electric energy is absorbed by each lamp.

No Actual Shortage of Gas.

The *American Manufacturer*, in editorially commenting on the apparent shrinkage of the natural gas supply in the Pittsburgh district, says that the present shortage of natural gas which is disturbing many mills around Pittsburgh is only temporary. In reality there is no shortage in the supply of gas, the wells of the Philadelphia Company are all productive and the pressure is constant; but an awkward shortage does exist in means of transportation. The Company is now trying to find opportunity to connect the new 36-inch pipe at Telford. For the sake of economy the new line is laid in the old right of way, and to accomplish this some of the old piping has occasionally to be removed. Consequently not only will there be no increase of gas until the new line is connected, but there is actually a decrease, owing to the cutting off of some of the old connections.

The Philadelphia Company had formed their plans with the expectation that by this time the Oliver mills and the Jones & Laughlin mills would be getting their supply of gas by private lines, and that the Shoenberger mills would draw from the Equitable Company, instead of which all three of these large consumers are still depending on the Philadelphia Company, thus materially increasing the difficulty of the present position.

The rumored attempt on the part of the Philadelphia Company to effect a change of hours in the mills is not at all a pronounced policy; on the contrary, news of it first reached headquarters by the papers. There is, however, a semi-private attempt to effect a compromise on an equitable distribution of the present supply of gas between mills and private houses while the trouble continues. At most, such an arrangement need only continue for a short time. Under the existing conditions it happens that the period of greatest demand for mills and that for private houses to some extent coincides. From 11 to 2 in the night the demand is very light; at 2 A.M. the mills begin to light up, and the demand grows steadily with the morning until at about 8 A.M. every well is brought to bear. In the afternoon the private demand grows less, and towards 6 P.M. it is very light. Now, since domestic houses are less easily changed, if any accommodation is made at all it must be made by the mills—that is to say, they must make their time of great demand coincident with the time of least private demand.

To repeat, it must not be supposed that there is any actual shortage of gas, or that there is any danger of shortage for some time to come; nevertheless, the rumors to that effect may bring about greater care in the use of gas, and prevent any avoidable waste.

THE AMERICAN
GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,

PROPRIETORS.

EDITOR—Jos. R. Thomas, C.E.

ASST. EDITOR—T. J. Cunningham.

MANAGER—C. E. Sanderson.

PUBLISHED ON EACH MONDAY OF THE YEAR AT

No. 42 Pine Street, New York.

This is a recognized official organ of
LIGHT, HEAT, STEAM, WATER SUPPLY,
VENTILATION, SANITARY IMPROVEMENT,
AND GENERAL SCIENCE

TERMS:

SUBSCRIPTION—Three Dollars per annum, in advance. Single copies, 10 cents.

AGENTS.

NEW YORK.—AMERICAN NEWS Co., 39 and 41 Chambers Street.
PHILADELPHIA—PRATT & Co., Corner Ninth and Arch Streets.
Germany.—B. WESTERMANN & Co., of New York.

MONDAY, NOVEMBER 11, 1889.

The Market for Gas Securities.

The market for city gas shares, presumably in consequence of an easier rate for money, took on a much firmer tone during the week, with the maximum figures being recorded towards the close. To-day (Friday) Consolidated is bid for at 91½, but holders seem disposed to accept not less than 92. Undoubtedly the near approach of dividend time—the declaration meeting will be held on the 27th inst—has also something to do with the advance. It is almost a certainty, as was remarked in this column some time ago, that the dividend will be at the rate of 5 per cent. per annum, and in the meantime we expect to see Consolidated go to 93 before the dividend announcement is made. Equitable and Mutual are also stronger. In Brooklyn shares no particular move has been made, but the dealings recorded, as a rule, have been put through at an advance. Chicago Trusts, which did fall to as low as 52, have recovered to 55½, and there is good reason for presuming that better figures will speedily appear. A very sensible move made by the Trust at the beginning of the month was to order a sharp cut in gas rates in the suburban districts supplied by the Company's branches.

A rumor has been circulated to the effect that New York capitalists have purchased control in the Columbus (O.) Gas Light and Coke Company. The rate said to have been obtained for 95 per cent. of the capital is returned at 140. The Herkimer (N. Y.) gas works have been purchased by the Empire State Gas Improvement Company, and the Norwich (N. Y.) plant has been sold to those in control of the local electric company. The gas and electric interests of Eastport (Me.) have also been consolidated. Baltimore gas does not do as well as it should, but we presume that the long delayed move in this security will be all the more pronounced when it does come. The shares are certainly worth a higher price than that now ruling—42¼ to 42½. There is some inquiry for Boston gas (common stock), and the bond issues are also in demand. Hartford gas is stronger, as is the case generally in respect to all classes of Eastern gas shares.

Gas Stocks.

Quotations by Geo. W. Close, Broker and Dealer in Gas Stocks,

16 WALL ST., NEW YORK CITY.

NOVEMBER 11.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

	Capital.	Par.	Bid	Asked
Consolidated	$35,430,000	100	91½	—
Central	500,000	50	—	—
" Scrip	220,000	—	—	—
Equitable	4,000,000	100	120	125
" Bonds	1,000,000	—	113	115
Harlem, Bonds	170,000	—	—	—
Metropolitan, Bonds	658,000	—	116	118
Mutual	3,500,000	100	102	105
" Bonds	1,500,000	—	100	102
Municipal, Bonds	750,000		—	—
Northern		50	—	—
" Bonds	150,000	—	—	100
Yonkers		50	112	—
Richmond Co., S. I.	346,000	50	60	70
" Bonds	20,000	—	—	—
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	109	110
Citizens	1,200,000	20	65	70
" S. F. Bonds	320,000	1000	100	103
Fulton Municipal	3,000,000	100	124	125
" Bonds	300,000		100	105
Peoples	1,000,000	10	74	75
" Bonds (5's)	368,000	—	100	—
" " (6's)	94,000	—	100	—
Metropolitan	1,000,000	100	90	—
Nassau	1,000,000	25	112	—
" Ctfs	700,000	1000	100	—
Williamsburgh	1,000,000	50	118	122
" Bonds	1,000,000	—	108	112
Out of Town Gas Companies.				
Boston (Mass.) Gas Co	2,500,000	500	240	—
Buffalo Mutual, N. Y.	750,000	100	90	95
" Bonds	200,000	1000	95	100
Citizens, Newark	1,000,000	50	155	160
" " Bonds	45,000	—	—	—
Chicago Gas Trust	25,000,000	100	55½	—
Cincinnati G. & C. Co.	6,000,000	100	214	218
Consumers Toronto	1,000,000	50	190	200
Central, S. F., Cal.			80	90
Capital, Sacramento, Cal.			58	
Consolidated, Balt.	11,000,000	100	42¼	42½
" Bonds	6,400,000		107	107½
Hartford, Conn	750,000	25	102	108
Jersey City	750,000	20	190	—
Laclede, St. Louis, Mo.	2,000,000	100	140	—
Louisville, Ky.	2,570,000	50	125	130
Little Falls, N. Y.	50,000	100	—	100
" Bonds	25,000	—	100	103
Montreal, Canada	2,000,000	100	200	208
Memphis (Tenn.) Gas	750,000	100	48	51
" Bonds	240,000	100	103	—
New Haven, Conn		25	200	—
Oakland, Cal.			35	35½
Peoples, Jersey City		—	60	61
" " Bonds			—	—
Paterson, N. J.		25	99	102
Rochester, N. Y.		50	99	100
Syracuse, N. Y.	500,000	25	—	—
St. Louis, Missouri	600,000	50	—	750
San Francisco Gas Co.			60	60½
San Francisco, Cal.	10,000,000	100	59¾	60
Washington, D. C.	2,000,000	20	200	208
Wilmington, Del.		50	200	208

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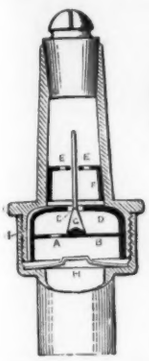

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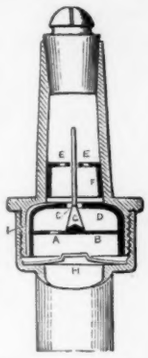
RHEOMETRIC GOVERNOR BURNER.



EXPLANATION OF CUT.—Gas passes through opening *A* in piston *B*, thence through opening *C* in inverted cup *D*, and through openings *E E* in guide-plate *F*; the flow being governed by the position of the conical valve *G* in respect to the opening *C*, a position which is automatically regulated by variations in the pressure of gas on piston *B*. Thus, if the pressure is excessive, the piston will be forced upward and the valve *G* elevated so as to restrict the freedom of the flow through opening *C*, the piston descending and the valve opening as the pressure is diminished.

This Burner is a Perfect Pressure Regulator, maintaining a uniform pressure at point of ignition at any pressure above $\frac{6}{10}$ in.

Careful Photometric tests show a gain of *fifteen per cent.* in illuminating power *over* the Argand burner. Warranted to give the same amount of light as other burners at from 25 to 50 per cent. less cost, and not to corrode or clog in any manner.

Manufactured in 2, 3, 4, 5, 6, 7, and 8 ft. sizes, and larger or smaller or intermediate fractional sizes to order.

Price, $6 per Dozen. Special Price and Free Sample to Gas Light Companies on Application.

In ordering Burners state whether for Coal Gas, Water Gas, Oil Gas, or Natural Gas; and also give specific gravity and illuminating power of same. Special Burners will be adjusted on demand for any quality of gas, and warranted to consume any required amount of such gas.

TESTIMONIALS.

THE PEOPLES GAS LIGHT CO., Brooklyn, N. Y., Mar. 22, 1889.

MR. H. W. RAPPLEYE: Dear Sir—In answer to your inquiries, permit me to say we have used your burners on our street lamps for the past six months, and are exceedingly pleased with them. We find that they practically control the delivery of gas under the varying pressures, and up to this time have generally given satisfaction.

Yours truly, EDWIN LUDLAM, President.

METROPOLITAN GAS LIGHT CO., Brooklyn, N. Y., Mar. 21, 1889.

MR. H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—In reply to your favor of 19th inst., I take pleasure in saying that the burners for street lamps, purchased of you by this Company, with which our district was covered about the 1st of November last, have, up to this time, come fully up to your representation of them.

The superiority of the light furnished by them, and the accuracy of their adjustment for controlling the quantity of gas consumed, are certainly to be commended.

Yours very truly, CHAS. S. STODDARD, President.

EAST RIVER GAS LIGHT CO., Long Island City, N. Y., Mar. 21, 1889.

H. W. RAPPLEYE, ESQ., 1345 Arch Street, Phila., Pa.: Dear Sir—In reply to your inquiry as to how I am pleased with your governor burners, I would say that I have used them for this Company since 1883, both for street lamps and private consumers. The majority of the burners put on the street lamps have been there since that time, without any trouble to us, and still remain in good condition. I am constrained to say that, so far as I am concerned, I consider them a perfect success; they accomplish all they are recommended for in your little pamphlet, a good many of which I have caused to be distributed amongst our consumers. I have tried various other governor burners, but have found none equal to yours in simplicity, durability, and perfect governing qualities. Very truly yours, CHAS. A. KITTLE, Gen. Manager.

MACON GAS LIGHT AND WATER CO., Macon, Ga., Mar. 22, 1889.

MR. H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—Replying to your inquiry of Mar. 19, would say that I have been using your rheometric governor burners since 1885, and am very well pleased with the results obtained from them. For the price charged they are the best governor burners I have tried, and seem to keep up the standard from year to year. Yours very truly,

A. E. BOARDMAN, Sec. and Treas.

SARATOGA GAS AND ELECTRIC LIGHT CO., Saratoga Springs, N. Y., Mar. 21, 1889.

H. W. RAPPLEYE, ESQ., 1345 Arch Street, Phila., Pa.: Dear Sir—We have used your rheometric governor gas burner on our street lamps since 1882, and consider them the best burner in the market. They give entire satisfaction. Very truly yours,

E. H. PETERS, Sec.

WILMINGTON COAL GAS CO., Wilmington, Del., Mar. 26, 1889.

H. W. RAPPLEYE, ESQ.: Dear Sir—Yours of 19th inst. received. In reply will say that our Company has used your rheometric governor gas burners since 1886, and find them to be a first-class burner for our public lamps. Very truly,

THOMAS CURLEY, Supt.

ST. JOSEPH GAS AND MFG. CO., St. Joseph, Mo., Mar. 27, 1889.

H. W. RAPPLEYE, Phila., Pa.: Dear Sir—We have been using your R. G. burners for several years past, and have found them uniform in every respect. We are convinced your governor does all you claim for it, and think them invaluable for street lighting.

Very truly yours, J. H. FARISH, Sec. and Treas.

Gloucester City, N. J., May 15, 1889.

MR. H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—The Gloucester City Gas Light Company use your rheometric gas burners on all city lamps. We believe them to be the best in use. Respectfully, S. R. MARTIN, Supt.

COMMITTEE ON TEMPLE, Broad and Filbert Sts., Phila., Pa., Mar. 13, 1889.

H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—We have been using your burners throughout the Masonic Temple for a number of years, and they have given us greater satisfaction than any heretofore used. We have no blowing when the gas is lighted and the burners properly attended to. They have been satisfactory to us.

Yours truly, SAML. W. WRAY, Sec.

SAN ANTONIO GAS CO., San Antonio, Texas, May 16, 1889.

H. W. RAPPLEYE, Phila., Pa.: Dear Sir—In reply to your inquiry of the 10th inst., will say that we have used your governor burners for our street lamps since 1884, and are well pleased with them. Yours truly, SAN ANTONIO GAS CO.,

per GUS. GUISECKE.

OFFICE BOARD OF GAS TRUSTEES, Wheeling, W. Va., May 23, 1889.

MR. H. W. RAPPLEYE, Phila., Pa.: Dear Sir—Replying to your letter of inquiry, I would say that we have been using your rheometric governor burners for the past six years, and find them to be the best governor burner ever introduced, as we have tried all kinds on our public lamps and buildings. As our stock is getting low, please forward us one gross per B. & O. Express, and oblige Yours truly, A. J. SEAMON, Sec.

OFFICE WILLIAMSPORT GAS CO., 250 Pine St., Williamsport, Pa., May 20, 1889.

MR. H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—We have used your rheometric gas burners for street lamps for the past six years, and take pleasure in recommending them as the best burners we have been able to secure; they give general satisfaction. Yours very truly, C. A. BYERS; Sec. and Treas.

OFFICE CRESTON GAS WORKS, Creston, Iowa, May 14, 1889.

H. W. RAPPLEYE, ESQ., 1345 Arch Street, Phila., Pa.: Dear Sir—Replying to your inquiry of May 10th, will say that after using your governor burners on our street lamps for two years, we feel we could not well get along without them. They are most certainly the best appliance of the kind we have ever used. Yours truly,

O. Q. HOLMAN, Manager.

OFFICE AUSTIN GAS LIGHT AND COAL CO., Austin, Texas, May 14, 1889.

MR. H. W. RAPPLEYE, Phila., Pa.: Dear Sir—Replying to yours of 10th inst., we take pleasure in stating that we have sold the R. G. Burners to our customers for about one year, and they are giving general satisfaction. They are economical, and are a good, practical burner. Yours truly, A. E. JUDGE, Supt.

OFFICE GAS LIGHT MANUFACTURING CO., Connersville, Ind., May 13, 1889.

MR. H. W. RAPPLEYE, Phila., Pa.: Dear Sir—Yours of May 10th, 1889, received. In reply, say that we have been using your governor burners on our street lamps since June, 1888, and that we are well pleased with them. We have had them in continuous use since that date, without replacement of even one burner. Yours, etc.,

ANTHONY WATT, Bookkeeper.

ATHENS GAS LIGHT CO., Athens, Ohio, April 13, 1889.

H. W. RAPPLEYE, ESQ., 1345 Arch Street, Phila., Pa.: Dear Sir—I use your burners exclusively upon our street lamps, where they give good results and better satisfaction than any other burner I have used. Yours truly, C. H. WELCH, Supt.

LOUISVILLE GAS CO., 336 West Green Street, Louisville, Ky., May 13, 1889.

H. W. RAPPLEYE, ESQ., Phila., Pa.: Dear Sir—Replying to your inquiry of 10th inst., I am pleased to say that I have in use on street lamps about 3,300 of your burners. I consider them the very best in the market. Respectfully, etc.,

A. H. BARRET, Engr.

ATHENS GAS LIGHT CO., Athens, Ga., May 17, 1889.

MR. H. W. RAPPLEYE, 1345 Arch Street, Phila., Pa.: Dear Sir—We have used your R. G. burners for several years on our street lamps, and find them exceedingly satisfactory. The item that concerns us most is the saving of gas; but beyond this we are indirectly benefited by the increased illumination from this lesser quantity of gas. We have induced some of our consumers to use them, and the result has always been satisfactory to them and generally to us, as a kicking customer is transformed into a contented one. Every gas man knows that a contented gas customer is the noblest work of the Creator.

Yours truly, C. D. FLANIGEN, Agt.

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This is a valuable and important work, a copy of which should be in the possession of every gas company in the country, whether large or small. As a book of reference it will be found invaluable. It is the only work of the kind which has ever been published in this country, and is most complete. Handsomely bound. Orders may be sent to

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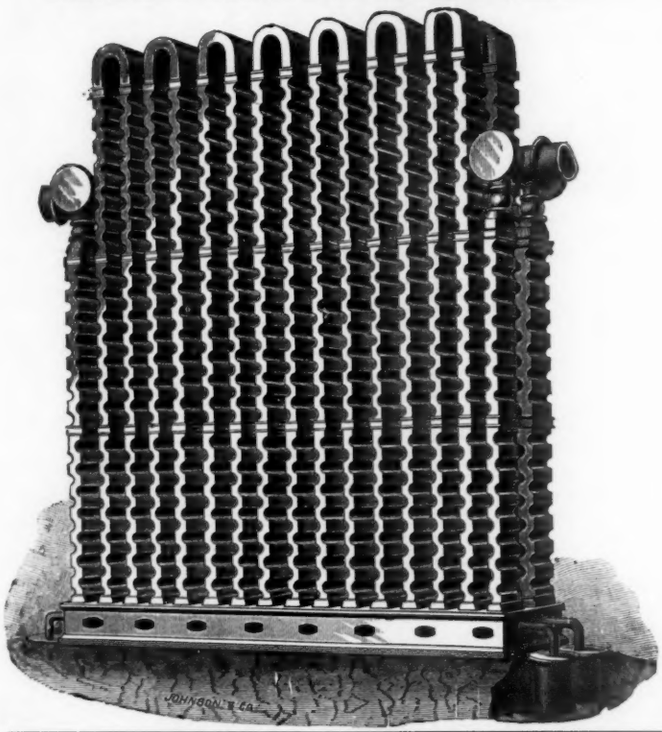

We desire to draw the attention of the gas community to the merits of the SINUOUS FRICTION CONDENSER. Companies intending to introduce new condensers into their works will do well to confer with us and examine plans and estimates before contracting for any other pattern The FRICTION CONDENSER is now in use at the gas works located in the following places:

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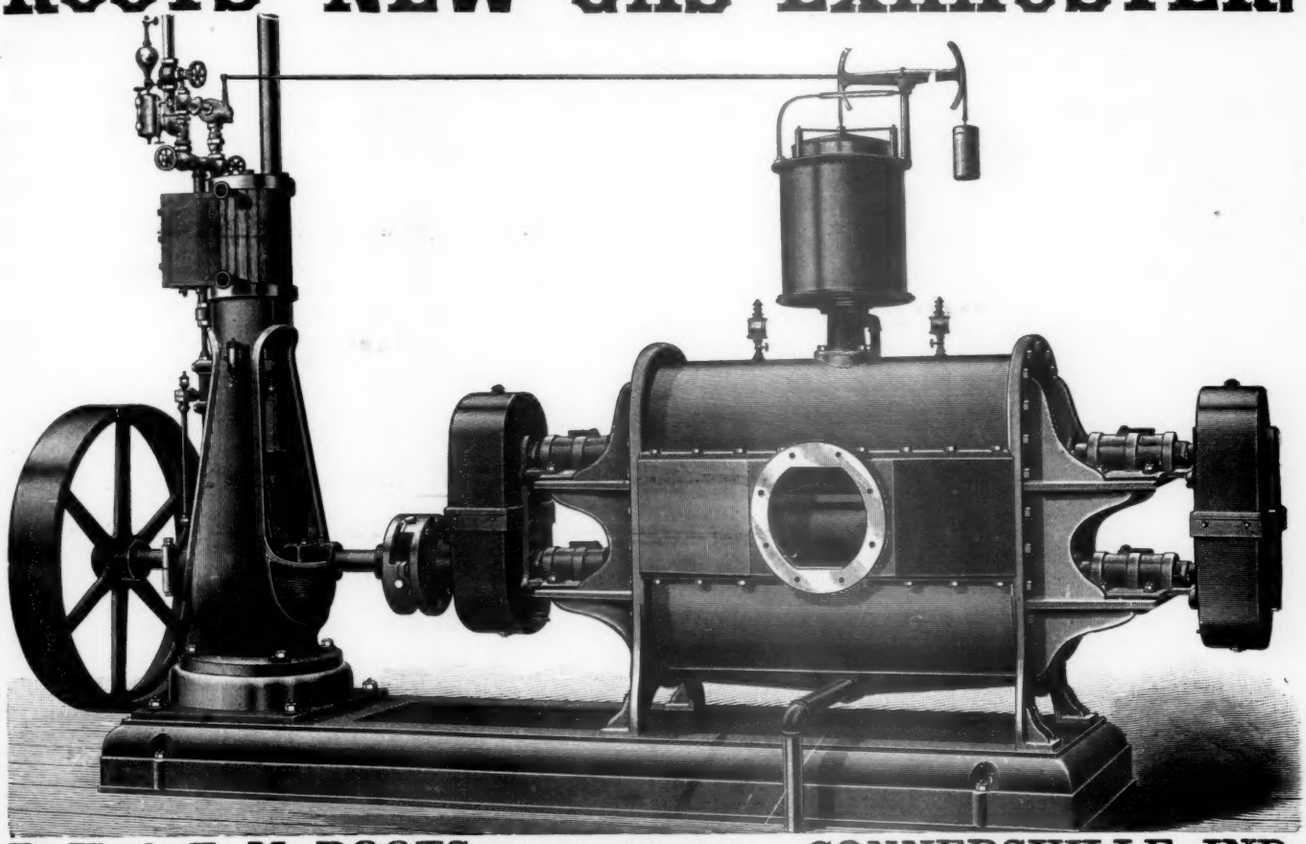

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A very general demand exists, in both large and small Gas Works, for an apparatus that will be absolutely efficient in the removal of the tar which passes the hydraulic main and condenser. Many attempts have been made to accomplish this, but, I believe, without success, until the introduction, five years ago, in England, of the C. & W. Walker Patent Tar and Carbonic Acid Extractor. During these years this apparatus has been adopted by many of the most prominent Engineers, not only in England, but also on the Continent of Europe and in other parts of the world. It is only necessary to give here a partial list in order to convince any intelligent American Gas Engineer that this machine must have succeeded fully in accomplishing the desired results.

The following Engineers have personally given permission to refer to them:

G. C. Trewby, Esq., Engineer-in-Chief of the Gas Light and Coke Co., London. The manufacturing plant at Beckton is built in complete sections of 3,000,000 cubic feet capacity each. A Walker Tar Extractor has been fitted to each one of these sections. This was done after a long and thorough trial on one of its sections. The Tar Extractor has been supplied to other works of the Gas Light and Coke Co., including those of which John Methven, Engineer of the Gas Light and Coke Co. at the Nine Elms Station, is in charge. Also to G. E. Stevenson, Peterborough Gas Works; B. Green, Mitcham and Wimbledon Gas Works; W. H. Smith, Bedford Gas Works; F. Linging, Norwich Gas Works; J. T. Browning, Colchester Gas Works; S. B. Darwin, Portsmouth Gas Works; J. McCrae, Dundee Gas Works; W. J. Wells, Stamford Gas Works; J. M. Darwin, Longton Gas Works; J. Paterson, Warrington Gas Works; and J. Coulter, of the Dundalk Gas Works. All of the foregoing gas works are located in Great Britain.

Mr. Charles A. Gerdenier, Superintendent of the Bridgeport (Conn.) Gas Light Company, writes as follows, under date of Dec. 3, 1887:

"The C. & W. Walker Tar and Carbonic Acid Extractor has been in operation at these works for the past six weeks, and is an unqualified success. It removes every particle of Tar from the gas in once passing through the apparatus, and a large percentage of the Carbonic Acid. I also feel quite sure that it prevents the formation and deposit of Naphthaline, because since I started the Washer I have had no stoppages from this cause. These works have been seriously troubled with Tar for many years, and I have used several kinds of apparatus and every expedient which has come to my attention for dealing with the difficulty, but without success. The Walker apparatus occupies comparatively small space, is less expensive than other systems, and requires but little attention. I carry 2½-inch seal, and have an automatic tar delivery valve. This Tar Extractor is indispensable to gas makers."

I have taken the Agency for the United States for this apparatus, and am now prepared to make contracts to erect it on the premises of any Gas Company. It would be manufactured in the following sizes:

No. 1,	50,000	to	100,000	cu. ft.	per	24 hrs.,	3	ft.	square,	5 ft. deep.
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No. 3,	"	"	250,000	"	"	"	5	"	"	" "
No. 4,	"	"	500,000	"	"	"	6	"	"	" "
No. 5,	"	"	750,000	"	"	"	7	"	"	" "
No. 6,	"	"	1,000,000	"	"	"	8	"	"	" "
No. 7,	"	"	1,250,000	"	"	"	9	"	"	" "
No. 8,	"	"	1,500,000	"	"	"	10	"	"	" "
No. 9,	"	"	2,000,000	"	"	"	12	"	"	" "
No. 10,	"	"	3,000,000	"	"	"	15	"	"	" "

This Tar Extractor will perform its work with about one-fourth the usual back-pressure heretofore required. It is simple in construction, and can be supplied at a very reasonable price—less than any other ever before introduced. Satisfactory results will be guaranteed in every instance.

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Decatur Gas Lt & Coke Co.	Decatur, Ill.
Niles Gas Light Co.	Niles, Mich.
Newton Illuminating Co.	Newton, Kansas.
Wellington Light & Heat Co.	Wellington, Kansas.
Chippewa Falls Gas Lt. Co.	Chippewa Falls, Wis.
Elkhart Gas Lt & Coke Co.	Elkhart, Ind.
Madison City Gas Light Co.	Madison, Wis.
South Bend Gas Light Co.	South Bend, Ind.
Sheboygan National Gas Co.	Sheboygan, Wis.
Salina Gas Light Co.	Salina, Kansas.
The Rathbun Co	Deseronto, Prov. Ont.
Jefferson City Gas Lt. Co	Jefferson City, Mo.
Mankato Gas Light Co.	Mankato, Minn.
Lima Gas Light Co.	Lima, Ohio.
Minneapolis Gas Light and Coke Co.	Minneapolis, Minn.
Bellevue Water and Fuel Gas Light Co.	Bellevue, Campbell County, Ky.
Bucyrus Gas Lt. & Fuel Co.	Bucyrus, Ohio.
Morris Gas Co.	Morris, Ill.
Los Angeles Gas Co.	Los Angeles, Cal.
San Diego Gas Fuel & Electric Lt. Co.	San Diego, Cal.
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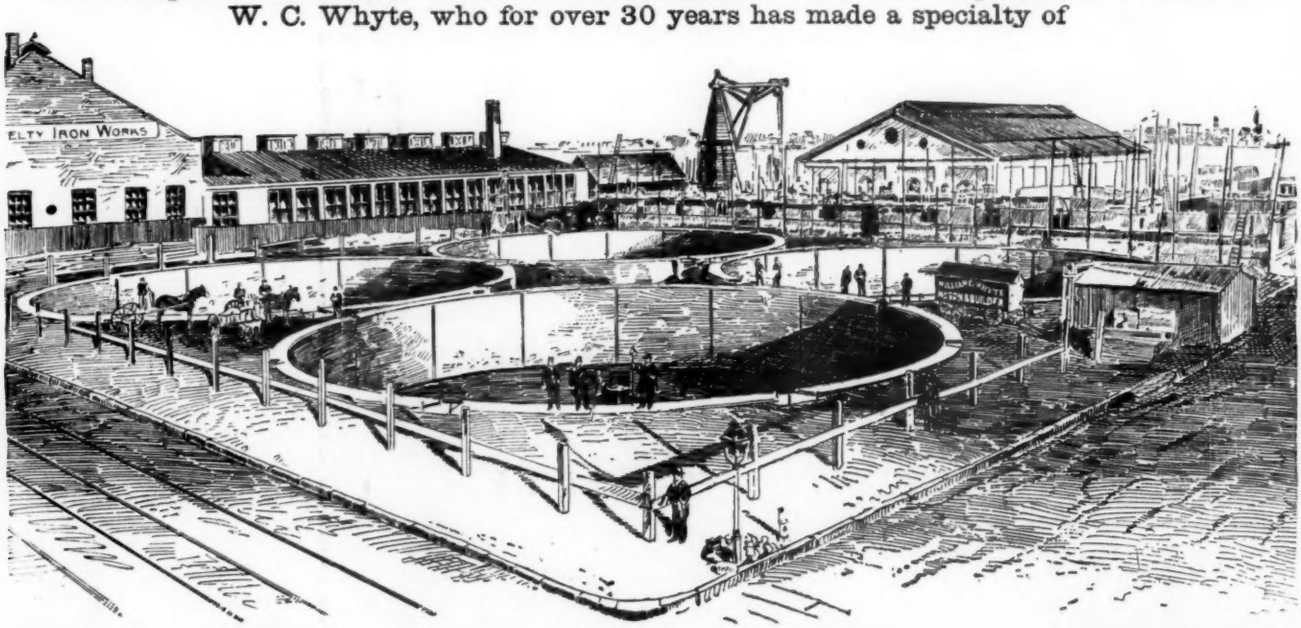

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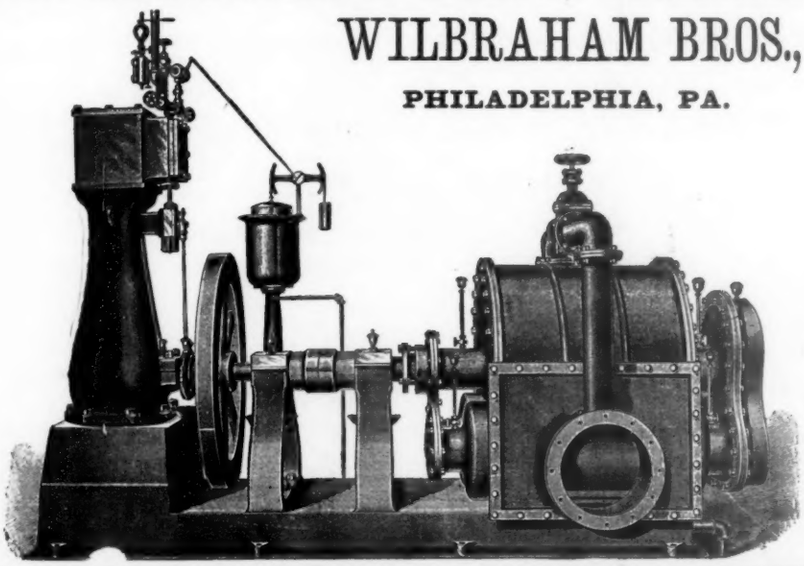

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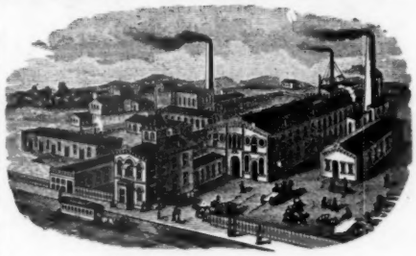

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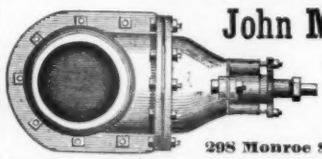

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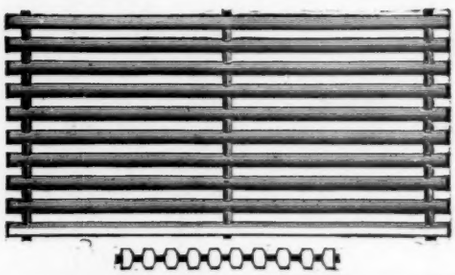

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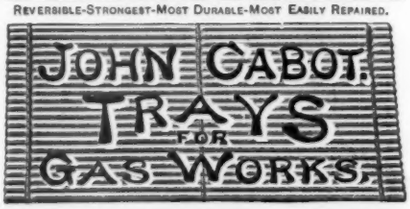

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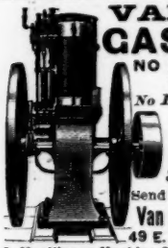

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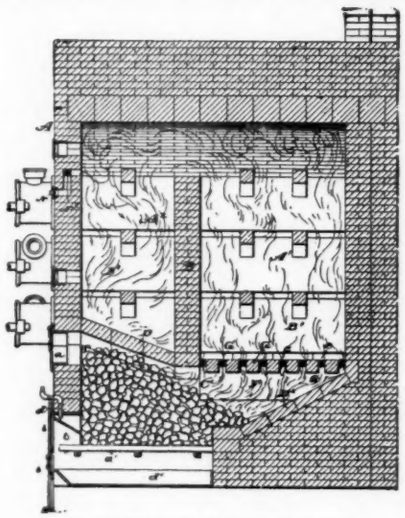

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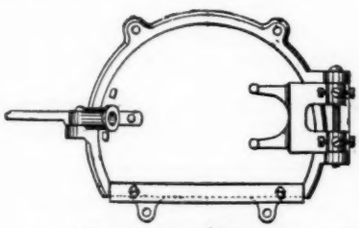

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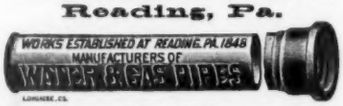

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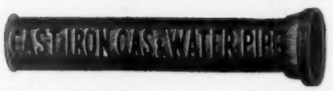

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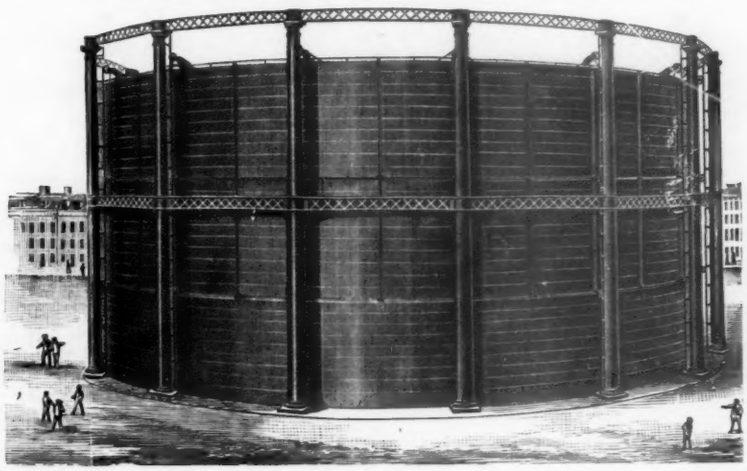

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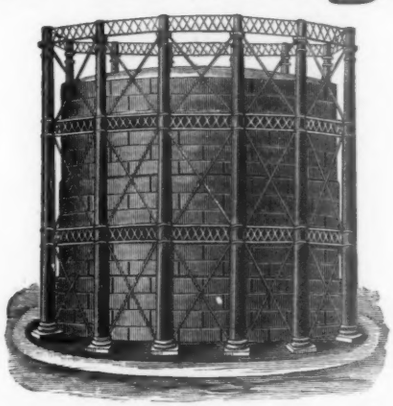

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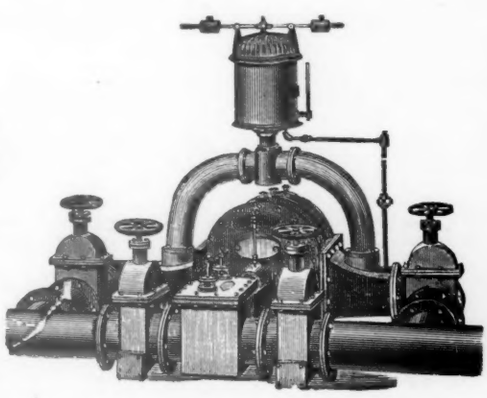

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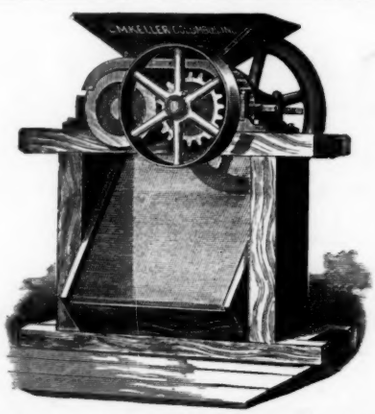

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37 in. high.	12 in. high.	12 in. high.	24 in. long.	36 in.
20 in. wide.	17¼ in. wide.	18 in. wide.	21 in. wide.	
	12 in. deep.	13 in. deep.		

This Stove has four burners on top, and double oven burner.

Consumption of gas with all burners in use, 42 feet per hour, at 1 inch pressure.

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All Fittings are Nickel-Plated.

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SIZE.

Stove.	Oven.	Roaster.	Top.	Length over Extension Shelves.
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17 in. wide.	14¼ in. wide.	15 in. wide.	16 in. wide.	
	12 in. deep.	13 in. deep.		

This Stove has three boiling burners in the Top or Hot Plate, and one single oven burner.

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The consumption of this Stove is 35 cubic feet per hour at 1 inch pressure, with all Burners in use.

All Fittings are Nickel-Plated.

"RADIANT" BOILING STOVE, WITH REGENERATIVE BURNER.

Size, 6¼ inches diameter, 5 inches high. Consumption, 6 feet per hour at 1 in. pressure.

HOT PLATE, No. 111.

Size, 36 in. long, 12 in. wide, with three double burners, 6 taps.

Consumption, with all burners in use, 36 cubic feet per hour, with 1 in. pressure in supply pipe should be used where the pressure is 1 in. or over.